

Submarine Assurance Framework

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■ *Section 1*
Scope of assurance

1.1 Scope

1.1.1 Lloyd's Register (LR) Submarine Assurance is independent third-party assurance based on the principles of Classification and may be defined as independent verification of the design, construction and material state of a submarine for compliance with project specifications, Rules, Codes and standards relating to submarine safety in defined operating conditions.

1.1.2 Submarine Assurance is concerned with verification of requirements relating to the submarine structure, its systems, equipment and components and as such does not extend to the verification of requirements relating to the competence or effectiveness of embarked persons or operational matters.

1.1.3 Submarine Assurance may cover the full submarine lifecycle, with verification of requirements through design and construction and thereafter in-service by means of survey and inspection, or may be limited to specific lifecycle phases as required.

1.1.4 Submarine Assurance may cover all submarine systems or may be limited to specific systems within the submarine as required.

1.1.5 Submarine Assurance is delivered through LR's Submarine Assurance Framework.

■ *Section 2*
Applicability of assurance

2.1 Applicability

2.1.1 Submarine Assurance is applicable to naval submarines designed and constructed for the purpose of carrying and operating naval systems.

2.1.2 Submarine Assurance is not applicable to submersibles, swimmer delivery systems and dive support systems which are covered by LR's *Rules and Regulations for the Construction & Classification of Submersibles & Diving Systems, July 2021* or to remotely controlled or autonomous unmanned underwater systems which are covered by LR's *ShipRight Procedure Code for Unmanned Marine Systems*.

■ *Section 3* **Conditions of assurance**

3.1 Submarine assurance

3.1.1 In the absence of an international regulatory regime for naval submarines, Submarine Assurance is provided within the context of a Navy's Submarine Safety Management System which addresses safety related policies, processes, people, systems and equipment.

3.1.2 Submarine Assurance therefore assumes the existence of a Submarine Safety Management System, incorporating or supported by a Submarine Safety Assurance System, which together deliver submarine safety throughout the lifecycle of the submarine.

3.1.3 The scope of Submarine Assurance offered by LR is concerned with all or part design, construction and maintenance of the submarine and its systems and does not provide assurance for other aspects affecting submarine safety such as personnel, training or procedures. Therefore, Submarine Assurance offered by LR is to be provided within the context of a Submarine Safety Assurance System addressing all aspects of assurance relevant to submarine safety. Without an appropriate Submarine Safety Assurance System in place, Submarine Assurance cannot be offered by LR.

3.1.4 Submarine Assurance also assumes that the submarine designer, builder or maintenance organisation requesting Submarine Assurance operates an established and approved Quality Assurance System capable of delivering a consistent and acceptable level of product quality. Without an appropriate Quality Assurance System in place, Submarine Assurance cannot be offered by LR.

3.1.5 Submarine Assurance also assumes that the submarine designer requesting Submarine Assurance employs established and recognised Systems Engineering processes capable of transforming an operational need into a detailed system design through a logical and structured sequence of decisions and activities. Without appropriate Systems Engineering processes in place, Submarine Assurance cannot be offered by LR.

■ *Section 4* **Certification of assurance**

4.1 Submarine Assurance Report

4.1.1 On satisfactory completion of LR's Submarine Assurance activities a Submarine Assurance Report will be issued by LR detailing the scope of assurance, any key assumptions and any non-compliances.

4.2 Submarine Assurance Certificate

4.2.1 On satisfactory completion of LR's Submarine Assurance activities a Submarine Assurance Certificate will be issued summarising the verification activity carried out by LR and referencing the Submarine Assurance Report.

Section

- 1 **Framework overview**
- 2 **Framework structure**
- 3 **Framework goals**
- 4 **Framework processes**

■ Section 1 Framework overview

1.1 Submarine Assurance Framework

1.1.1 The LR Submarine Assurance Framework is a goal-based framework used to establish the requirements for, and scope of, the assurance activities to be carried out independently by LR during the design and construction of a submarine as part of LR's Submarine Assurance.

1.1.2 The framework may be implemented as part of the Submarine Safety Management System owned and operated by a Navy and incorporating a Submarine Safety Assurance System or implemented as part of a Submarine Safety Assurance System owned and operated by a designer, builder or maintenance organisation which forms part of the Submarine Safety Management System owned and operated by a Navy.

1.1.3 The framework is not a substitute for either the Submarine Safety Management System or the Submarine Safety Assurance System. Unlike LR's *Rules and Regulations for the Classification of Naval Ships, January 2021, incorporating Notice No. 1, 2, 3 & 4*, the framework itself does not provide technical requirements and cannot be used in isolation to provide assurance of the acceptability of a design, construction or material state of a submarine.

1.1.4 The framework may be applied over the full submarine lifecycle, commencing with verification activities during design and construction of the submarine and thereafter while in-service by means of survey and inspection, or may be limited to specific lifecycle phases as required.

1.1.5 In accordance with a defined and agreed Submarine Assurance Plan, the framework ensures that project specifications, Rules, Codes and standards proposed for the design and construction of the submarine are appropriately justified against an established and recognised set of Goals, Functional Objectives and Performance Requirements for submarine safety consistent with those defined in the Naval Submarine Code (NSubC).

1.1.6 Following justification of the project specifications, Rules, Codes and standards to be applied, the framework establishes where LR's normal verification activities – Design Verification and Product Verification – are to be implemented in order to ensure the detailed requirements within those project specifications, Rules, Codes and standards themselves are verified during design and construction of the submarine.

1.1.7 The framework may be applied to all submarine systems or may be restricted to specific systems within the submarine as required. Where the framework is applied to specific systems only, then in addition to consideration of the Goals, Functional Objectives and Performance Requirements applicable to those specific systems, the Goals, Functional Objectives and Performance Requirements applicable to the 'Whole Boat' and thus by definition applicable to all systems within the submarine, must also be considered.

1.1.8 Following the application of the framework, LR will issue a Submarine Assurance Report and a LR Submarine Assurance Certificate which will identify the scope of application with respect to the submarine safety Goals, Functional Objectives and Performance Requirements together with the project specifications, Rules, Codes and standards that have been verified and details of any agreed deviations there from.

1.1.9 The framework has been developed using a number of open sources including LR's existing Classification Rules and Regulations where considered relevant to submarines; International Standards; relevant technical requirements documented in unrestricted National Government Standards; industry best practice based on relevant internal competence and expertise overseen by individual industry experts involved through either the LR Naval Ship Technical Committee, or its sub-committees or working groups.

Section 2 Framework structure

2.1 Goal based requirements

2.1.1 The Submarine Assurance Framework comprises a hierarchical set of Goal based requirements to be satisfied in the design, construction or maintenance of a submarine as relevant, supported by planning and verification processes by which LR will provide independent assurance that those requirements have been satisfied.

2.1.2 The Goal based requirements of the framework are consistent with those of the NSubC, however unlike the NSubC, the framework also defines the planning and verification processes which may be used to demonstrate that the Goal based requirements of the framework have been satisfied.

2.1.3 Consistency between the Goal based requirements of the framework and the Goal based requirements of the NSubC allows compliance with the NSubC to be readily demonstrated.

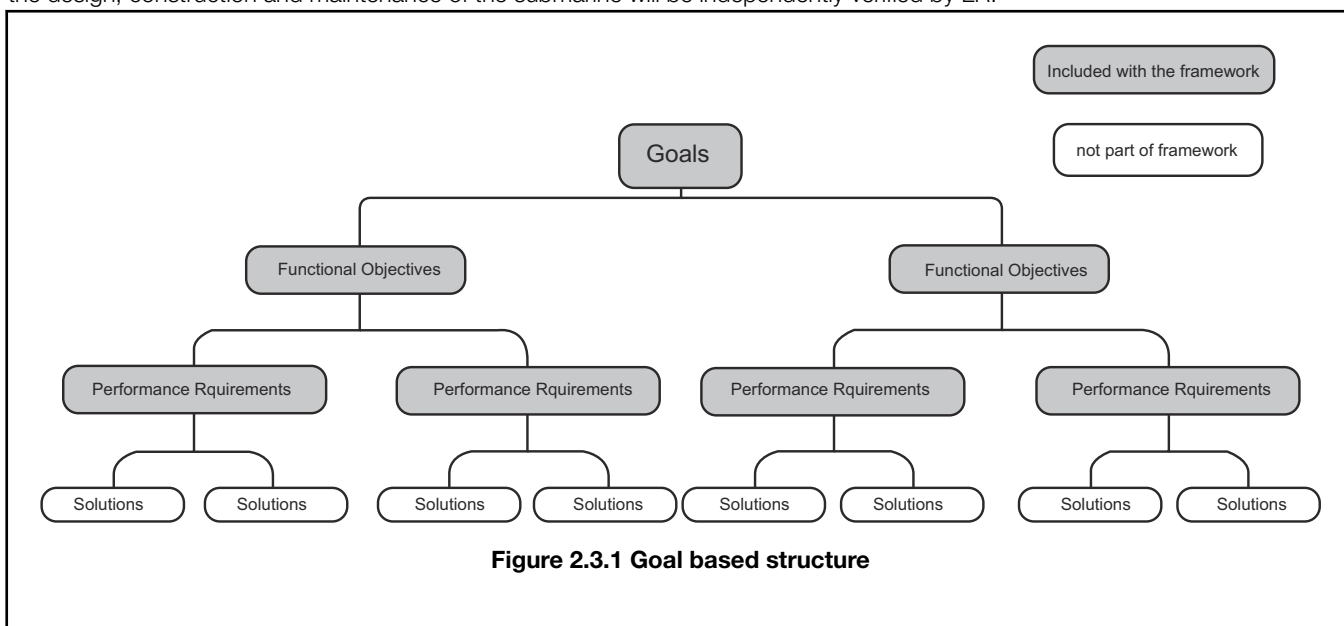
Section 3 Framework goals

3.1 Goal based hierarchy

3.1.1 The Submarine Assurance Framework defines a hierarchical set of Goal based requirements relevant to the design, construction or maintenance of a submarine. The requirements relate to key safety related aspects of submarine design, construction and maintenance consistent with those defined in the NSubC and are to be agreed as appropriate and sufficient for the purposes of the project by the key project stakeholders.

3.1.2 As is common with Goal based requirements, the framework provides Functional Objectives which are considered to satisfy the Goals. Performance Requirements are provided which are considered to satisfy the Functional Objectives.

3.1.3 The Performance Requirements are qualitative and independent of technical or operational solutions, which allows a range of solutions to be proposed, justified and accepted. Performance Requirements are satisfied through the application of appropriate project specifications, Rules, Codes and standards which are selected and proposed by the designer, builder or maintenance organisation. The relevance and application of the project specifications, Rules, Codes and standards to and during the design, construction and maintenance of the submarine will be independently verified by LR.



■ *Section 4* **Framework processes**

4.1 Overview

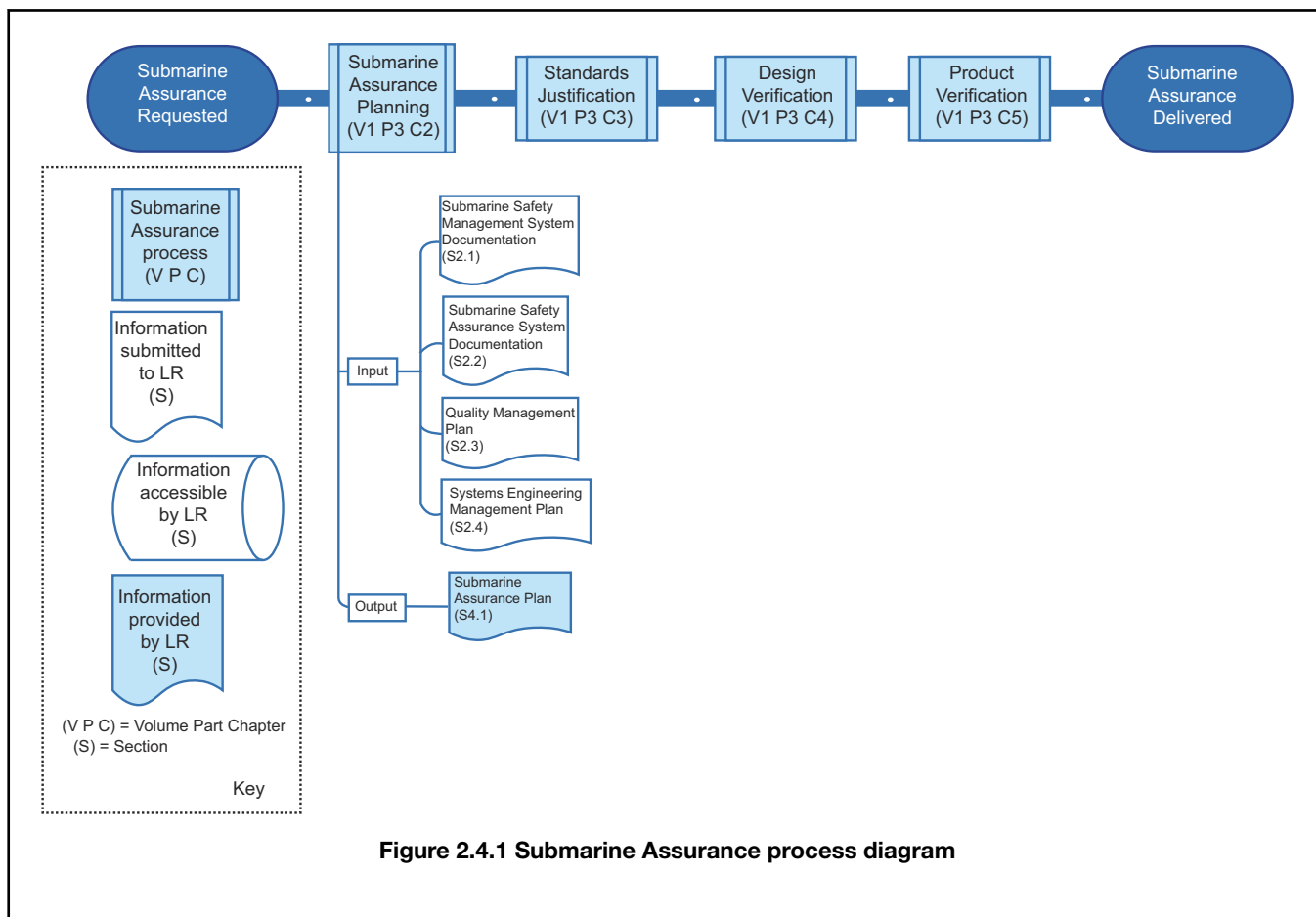
4.1.1 Assurance that the Goals, Functional Objectives and Performance Requirements of the Submarine Assurance Framework have been satisfied during the design, construction and maintenance of the submarine is achieved by means of three related but independent verification processes: Standards Justification, Design Verification and Product Verification, which are applied according to a defined and agreed Submarine Assurance Plan.

4.1.2 The Submarine Assurance Planning process establishes the intentions and scope of the assurance activities to be carried out with respect to the submarine systems, equipment and components together with the roles and responsibilities of the entities involved.

4.1.3 The Standards Justification process is intended to ensure that the project specifications, Rules, Codes and standards proposed and considered by the designer, builder or maintenance organisation to satisfy the Performance Requirements are considered by LR to be relevant and appropriate for the operating context, design, construction or maintenance of the submarine. In verifying the Standards Justification, LR reviews the justification provided by the designer, builder or maintenance organisation for the use of the proposed project specifications, Rules, Codes and standards in meeting the Performance Requirements. Based on the justification together, with supporting evidence, and where necessary examination of the proposed project specifications, Rules, Codes and standards, compliance with the Performance Requirement(s) will be verified as appropriate.

4.1.4 The Design Verification process is intended to ensure that the detailed design of the submarine satisfies the project specifications, Rules, Codes and standards selected and proposed by the designer and previously verified by LR during the Standards Justification process.

4.1.5 The Product Verification process is intended to ensure that the construction of the submarine and the products used in the construction and maintenance of the submarine satisfy the verified design and the project specifications, Rules, Codes and standards selected and proposed by the designer, builder or maintenance organisation and previously verified by LR during the Standards Justification process.



Section

1 Terms, definitions and acronyms related to Part 1

■ Section 1 Terms, definitions and acronyms related to Part 1

1.1 Definitions

1.1.1 The following terms and definitions are relevant:

- **Assurance activities.** Any activity undertaken by LR under the Submarine Assurance Framework.
- **Builder.** The organisation which constructs and delivers the submarine. Generally responsible for the Safety Assurance System during construction including product supply chains.
- **Designer.** The organisation with responsibility for designing the submarine. Generally responsible for the Safety Assurance System during design.
- **Framework.** LR's Submarine Assurance Framework.
- **Maintenance organisation.** The organisation with responsibility for maintenance of the submarine and generally responsible for the Safety Assurance System during maintenance.
- **Manufacturer.** The manufacturer and supplier of supply chain products required to construct the submarine.
- **Naval Administration.** The Government Department of the State responsible for providing safety Policy and Governance for naval submarines.
- **Naval Submarine Code.** An internationally recognised goal-based Code which provides an accepted baseline against which a submarine can be demonstrated to be safe to operate, recognising the risk arising from their unique operational requirements, through a process covering design, manufacture and maintenance, against a defined scope and Concept of Operations.
- **Navy.** The organisation that operates the submarine. Generally responsible for the Safety Assurance System during operation.
- **Non-compliance.** Intended or unintended deviation from the project specifications, Rules Codes and standards. See *Vol 1, Pt 3, Ch 7 Terms, Definitions and Acronyms*.
- **Owner.** The organisation that owns the submarine. Generally responsible for the Safety Management System.
- **Product.** All materials, components, equipment, assemblies and systems used in the construction of a submarine.
- **Product manufacturer.** The organisation with responsibility for the manufacturing of products to be used in the construction of the submarine.
- **Solution.** Project specifications, Rules Codes and standards, the requirements of which, which when correctly applied, are considered to satisfy framework Performance Requirements and therefore the corresponding Functional Objectives and Goals of the framework.

1.2 Acronyms

1.2.1 The following acronyms are relevant:

- **DV.** Design Verification.
- **NSubC.** Naval Submarine Code
- **PV.** Product Verification.
- **SJ.** Standards Justification.

*Section***1 Responsibilities****2 Activities****■ Section 1
Responsibilities****1.1 Assurance stakeholders**

1.1.1 The Submarine Assurance Framework is not a substitute for the Submarine Safety Management System or the Submarine Safety Assurance System, but can make a significant contribution to a safety argument which demonstrates that the submarine is 'safe to operate' in the defined operating context. Responsibility for the safety argument throughout the submarine lifecycle lies with the submarine Owner.

1.1.2 The submarine Owner, designer, builder, maintenance organisation and Navy are to give LR Surveyors every facility and necessary access to carry out their verification activities. They should familiarise themselves with the Submarine Assurance Plan and, where appropriate, arrange for all sub-contractors and product suppliers to do the same.

1.1.3 While recognising that information related to naval submarines will by its nature be sensitive, LR will require access to information necessary to allow the verification activities defined within the Submarine Assurance Plan to be carried out. LR respects intellectual property and national requirements for the protection of information.

1.1.4 Where full responsibility for assurance has not been delegated to LR, and the Naval Administration or another Recognised Organisation undertakes verification activities such as assessments, audits, inspections, surveys or issues certification relevant to the scope of the activities to be carried out by LR as defined within the Submarine Assurance Plan, LR is to be provided with the necessary details to allow verification activities defined within the Submarine Assurance Plan to be carried out.

1.1.5 Where particular verification activities are carried out in isolation in order to provide specific and targeted verification of certain systems, equipment and components it is the responsibility of the Owner or Navy to ensure that such verification is consistent with, and carried out within, the context of the Submarine Safety Management System in order to avoid any gaps between different verification activities undertaken by different entities.

**■ Section 2
Activities****2.1 Verification Plan**

2.1.1 In accordance with an agreed Submarine Assurance Plan, the verification activities to be carried out by LR may be carried out over the full submarine lifecycle or limited to specific lifecycle phases as defined.

2.1.2 It is important that a consistent and rigorous approach to verification is applied across the submarine lifecycle and that verification activities carried out during the in-service and maintenance phases of the submarine lifecycle are commensurate with those applied during design and construction.

2.2 Verification activities

2.2.1 The level of rigor in verification is to be commensurate with the safety criticality of the systems, equipment and components categorised in accordance with the requirements of the Submarine Safety Assurance System.

2.2.2 Verification activities carried out independently by LR may include independent analysis, design review, audit, survey, inspection and testing as appropriate for the submarine lifecycle phase and requirements to be verified.

2.2.3 Verification activities carried out independently by LR are not a substitute for second party verification carried out by the submarine designer, builder, or maintenance organisation.

*Section***1 Concept****2 Design****3 Manufacture and construction**

**■ Section 1
Concept****1.1 Operating context**

1.1.1 The Concept of Operations Statement (ConOpS) is the Owner's vision of how the submarine is to be operated and maintained throughout its life-cycle. It is to be produced by the Owner and shall be agreed with the Naval Administration. It is to be provided for each stage of the Submarine Assurance process to inform verification activities.

1.1.2 System operational concepts derived from the ConOpS are to be provided by the designer to ensure that system functions, dependencies, operating modes and criticality are adequately defined to perform verification activities. They are to be provided at the design stage and maintained for construction and through life.

**■ Section 2
Design****2.1 Verification activities**

2.1.1 Verification activities carried out by LR during the design phase of the submarine lifecycle are at the request of either the submarine designer or the Owner of the submarine.

2.1.2 Verification activities carried out by LR during the design phase of the submarine lifecycle are either verification activities carried out to confirm the suitability of proposed project specifications, Rules, Codes and Standards (Standards Justification), verification activities carried out to confirm that the requirements within project specifications, Rules, Codes and Standards have been satisfied in the design of the submarine (Design Verification), or verification activities carried out to confirm that the design is consistent with the operational envelope.

2.1.3 Verification activities are to be undertaken in accordance with the Standards Plan and Justification Document, and with the Design Verification Plan, which are to include whole boat requirements. LR will advise the designer and Naval Administration where the design is not in compliance with the project specifications, Rules, Codes and Standards. The design is to be modified or a suitable engineering justification provided.

2.1.4 Verification activities carried out by LR during design of the submarine are based on review, examination and interrogation of information related to the submarine design submitted to LR or accessible to LR as appropriate.

2.1.5 Prior to verification, LR is to be satisfied that the capability, organisation and facilities of the submarine designer are such that acceptable standards can be obtained for the design of the submarine systems, equipment and components.

2.1.6 Prior to verification, LR is to be satisfied that the submarine designer has established and documented quality assurance processes for submarine design in place which include project management, change control, design, design review and design approval processes. The quality assurance processes are to include both second-party and third-party assurance.

2.1.7 Prior to verification, LR is to be satisfied that the submarine designer has established and documented system engineering processes in place which include requirements engineering, risk management, design management, configuration management and verification and validation processes.

2.1.8 The submarine designer is responsible for maintaining copies of the design information, including project specifications, Rules, Codes standards, policy documents, analysis, calculations, drawings and records, and is to make these available to LR on request.

■ *Section 3* **Manufacture and construction**

3.1 Verification activities

3.1.1 Verification activities carried out by LR during the manufacturing and construction phases of the submarine lifecycle are at the request of either the submarine builder or the Owner of the submarine.

3.1.2 Verification activities carried out by LR during the manufacturing and construction phases of the submarine lifecycle are verification activities carried out to confirm that the construction of the submarine and the manufacturing of systems, equipment and components used in the construction of the submarine satisfy the previously approved design and the requirements within previously verified project specifications, Rules, Codes and Standards.

3.1.3 Verification activities are to be undertaken in accordance with the Product Verification Plan. LR will advise the equipment manufacturer or builder and Naval Administration where the systems, equipment and components are not in compliance with the design documentation, project specifications, Rules, Codes and Standards. The items identified are to be modified or a suitable engineering justification provided.

3.1.4 Verification activities carried out by LR during construction of the submarine, manufacturing of systems, equipment and components are based on periodical visits to the construction site or manufacturers works and as such LR's Surveyors may not be in continual attendance. Recognising that submarine construction and systems, equipment or component manufacturing are continuous processes, the submarine builder has the overall responsibility to the Owner for ensuring and documenting that the verification requirements of the Submarine Assurance Plan have been satisfied.

3.1.5 Prior to verification, LR is to be satisfied that the capability, organisation and facilities of the submarine builder and manufacturer are such that acceptable standards can be obtained for the construction of the submarine and its systems, equipment and components. The requirements of the Product Verification Plan are to be consistent with the builder's and manufacturer's quality systems.

3.1.6 Prior to verification, LR is to be satisfied that the submarine builder and manufacturer have established and documented quality assurance processes for submarine construction in place which include management, change control, equipment procurement, traceability, construction, inspection and testing processes. The quality assurance processes are to describe both second-party and third-party assurance.

3.1.7 The submarine builder and manufacturer are responsible for maintaining copies of approved documentation, certificates and records, and is to make these available to LR on request.

*Section***1 In-service and maintenance****■ Section 1
In-service and maintenance****1.1 Verification activities**

1.1.1 Verification activities carried out by LR during the in-service and maintenance phase of the submarine lifecycle are at the request of the Navy operating the submarine or the Maintenance Organisation.

1.1.2 Verification activities carried out by LR during the in-service and maintenance phase of the submarine lifecycle are verification activities carried out to confirm that the previously approved design and the requirements within previously approved project specifications, Rules, Codes and Standards continue to be satisfied while the submarine is in-service.

1.1.3 Verification activities are to be undertaken in accordance with the In-service Verification Plan. LR will advise the manufacturer or builder and Naval Administration where the systems, equipment and components are not in compliance with the design documentation, project specifications, Rules, Codes and Standards. The items identified are to be modified or a suitable engineering justification provided.

1.1.4 Verification activities carried out by LR while the submarine is in-service or undergoing maintenance are based on specific visits by LR's Surveyors.

1.1.5 Verification activities may be carried out periodically in accordance with an agreed schedule or whenever any significant repairs or renewals are made in order to confirm that the requirements within the project specifications, Rules, Codes and Standards continue to be satisfied.

1.1.6 Verification activities carried out periodically typically include surveys carried out:

- (a) Before the submarine is put into service;
- (b) During deep maintenance or extended maintenance;
- (c) During docking; and
- (d) Annually.

1.1.7 Verification activities carried out following any modifications or change in operating context and are to include Design Verification and Product Verification confirming that the design, the materials and the workmanship of the repairs and renewals are of suitable quality, free from defects and in accordance with applicable specifications, Rules, Codes and Standards.

1.1.8 Design verification is to be undertaken where the degraded state does not meet the original design requirements defined in design information and design verification records.

1.1.9 Prior to verification, LR is to be satisfied that the capability, organisation and facilities of the submarine maintenance organisation are such that acceptable quality and integrity can be obtained for the maintenance and repair of the submarine and its systems, equipment and components. The requirements of the In-service Verification Plan are to be integrated with the maintenance organisation's quality system.

1.1.10 Prior to verification, LR is to be satisfied that the Navy or the maintenance organisation has an established and documented maintenance management processes in place which include service and product procurement, configuration and change control, materials and equipment traceability, maintenance, inspection and testing processes.

1.1.11 Prior to verification, LR is to be satisfied that change control processes ensure that changes requiring update of the documentation relating to the submarine design or submarine operation are assessed to ensure that the update of the documentation is carried out at an appropriate frequency. Any changes to the ConOpS or operational envelope are to be incorporated prior to deployment of the submarine.

1.1.12 Prior to verification, LR is to be satisfied that configuration control processes ensure the traceability of materials and products following changes throughout the life of the components, equipment and systems.

1.1.13 The submarine Owner or maintenance organisation is responsible for maintaining a set of design and construction and in-service documentation and records to which LR will require access. Such records are to enable through-life material and

equipment traceability and confirmation that systems, equipment and components have remained within safe operating limits while in-service.

1.1.14 The Owner will be responsible for provision of an updated operational envelope to enable safe operation of the submarine, component, product or system following maintenance and repair.

Section

1 Terms, definitions and acronyms related to Part 2

■ Section 1 Terms, definitions and acronyms related to Part 2

1.1 Definitions

1.1.1 The following terms and definitions are relevant:

- **Concept of Operations Statement.** (ConOpS) details the Owner's vision of how the submarine is to be operated and maintained throughout the lifecycle of the submarine.
- **Degraded state. Degradation.** The physical condition of the submarine systems, equipment and components following an extended build period or period of in-service operation. Degradation can be from corrosion, exposure to chemicals, biological attack, material changes, creep, fatigue, erosion, wear. These may place restrictions on the Operational Envelope.
- **Design constraint.** Limitations imposed on design variables which result from decisions made during the design process. Imposed so that the design can be realised. These will be recorded in the Operational Envelope.
- **Evidence.** The results of documented activities undertaken by suitably qualified and experienced personnel from within the designer's, builder's, product manufacturer's or maintenance organisation's own organisation (second-party assurance) in order to demonstrate compliance with project specifications, Rules, Codes and standards. Evidence includes:
 - **Analysis.** Demonstration of compliance with defined requirements using appropriate analytical techniques. The analytical techniques and the results thereof are to be reviewed by LR or suitably qualified and experienced persons from an independent organisation acceptable to LR.
 - **Design audit.** Demonstration of compliance with defined requirements for design assurance. The results of the audit are to be reviewed by LR or suitably qualified and experienced persons from an independent organisation acceptable to LR.
 - **In-service experience.** Demonstration of compliance with defined requirements using performance data acquired under representative operational conditions which include normal, abnormal and emergency operation. The performance data and associated operational conditions are to be reviewed by LR or suitably qualified and experienced persons from an independent organisation acceptable to LR.
 - **Internal inspection.** Demonstration of compliance with defined requirements through physical examination. The results of the inspection are to be reviewed by LR or suitably qualified and experienced persons from an independent organisation acceptable to LR.
 - **Internal review.** Demonstration of compliance with defined requirements through examination of the design. The results of the examination are to be reviewed by LR or suitably qualified and experienced persons from an independent organisation acceptable to LR.
 - **Modelling and simulation.** Demonstration of compliance with defined requirements through an agreed modelling or simulation programme. The modelling or simulation programme, the input data and the results thereof are to be approved by LR or suitably qualified and experienced persons from an independent organisation acceptable to LR.
 - **Testing.** Demonstration of compliance with defined requirements through an agreed schedule of testing. The test schedule and the results thereof are to be approved and witnessed by LR or suitably qualified and experienced persons from an independent organisation acceptable to LR.
 - **Trials.** Demonstration of the performance of the submarine or its systems, equipment and components against defined requirements through an agreed programme of trials under representative operating conditions. The trials programme and the results thereof are to be approved and witnessed by LR or suitably qualified and experienced persons from an independent organisation acceptable to LR.
- **Project specifications.** Engineering requirements to be imposed upon submarine systems, equipment and components. Contained within engineering specification or the submarine specifications rather than published Rules, Codes or Standards.
- **Safety Criticality.** A category assigned to a system, equipment or component through a formal process. The level assigned is based on the impact on the submarine or embarked persons for defined operating conditions. (See Vol 1, Pt 4, Ch 3, 2 System and equipment categories)

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- **Verification activities.** Documented activities undertaken by LR or an independent organisation acceptable to LR (third-party assurance) in order to verify compliance with project specifications, Rules, Codes and standards. Verification activities include:
 - **Design Appraisal.** Verification of compliance with defined requirements through examination of the design by LR.
 - **Design review.** Verification of compliance with defined requirements through examination of the design by suitably qualified and experienced personnel from an independent organisation acceptable to LR.
 - **Document review.** Examination or audit of manufacturers records of production, measurement, testing and quality. Review is undertaken by LR.
 - **Independent analysis.** Verification of compliance with defined requirements using appropriate analytical techniques by LR or suitably qualified and experienced persons from an independent organisation acceptable to LR.
 - **Independent inspection.** Verification of compliance with defined requirements through physical examination by LR or suitably qualified and experienced personnel from an independent organisation acceptable to LR.
 - **Monitoring.** Verification of compliance with defined requirements through regular scheduled inspections of ongoing manufacturing activities by LR or suitably qualified and experienced personnel from an independent organisation acceptable to LR.
 - **Patrol.** Verification of compliance with defined requirements through unscheduled inspections of ongoing manufacturing activities by LR. The frequency and scope of patrol is determined from the results of verification activities.
 - **Survey.** Verification of compliance with defined requirements by LR using a combination of verification activities as appropriate.
 - **Witness of testing.** Verification of compliance with defined requirements through inspection of the physical testing performed by the manufacturer. Inspection is by LR or suitably qualified and experienced personnel from an independent organisation acceptable to LR. Production may be held until the verification activity is complete.
 - **Witness of process event.** Verification of compliance with defined requirements through inspection of a manufacturing activity or event, by LR or suitably qualified and experienced personnel from an independent organisation acceptable to LR. Production may be held until the verification activity is complete.
 - **Works approval.** Verification of a product manufacturer's or builder's quality assurance system, production processes and records together with testing of representative materials and processes and approval thereof by LR.

1.2 Acronyms

1.2.1 The following Acronyms are relevant:

None specific to this part.

*Section***1 General**

**■ Section 1
General****1.1 Verification activities**

1.1.1 With reference to the verification activities to be carried out by LR over the submarine lifecycle, the following Chapters describe the information to be submitted for review, the verification activities to be carried out and the resulting documentation to be issued.

Section

- 1 **Objective and scope**
- 2 **Information to be submitted**
- 3 **Submarine assurance planning**
- 4 **Documentation to be issued**

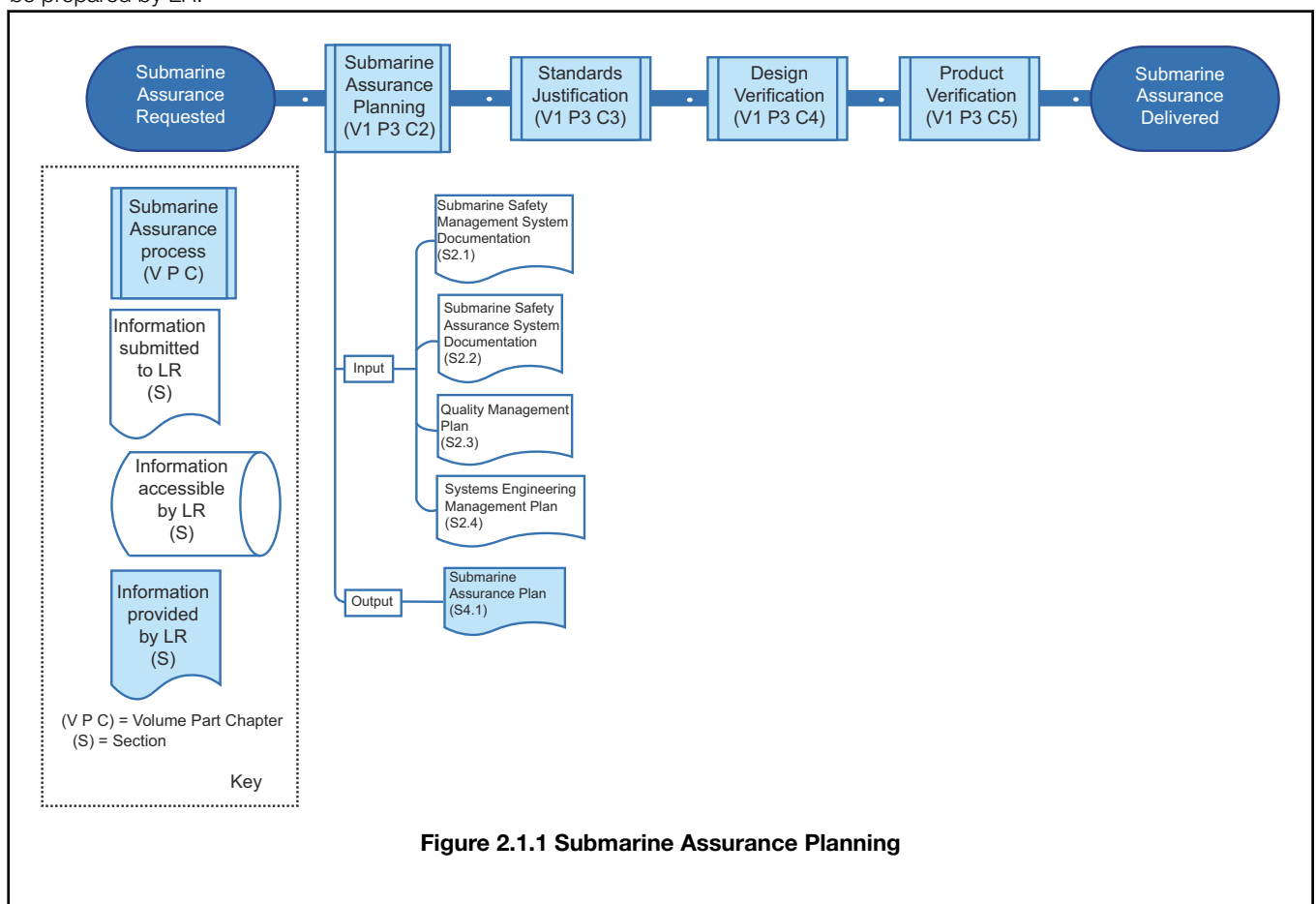
Section 1 Objective and scope

1.1 General

1.1.1 The Submarine Assurance planning process establishes the scope of the Submarine Assurance activities required to be carried out by LR.

1.1.2 The scope of Submarine Assurance activities to be carried out are proposed by the submarine Owner, designer, builder or maintenance organisation according to the submarine lifecycle phase or phases for which Submarine Assurance is required and agreed by LR.

1.1.3 A Submarine Assurance Plan documenting the scope of the Submarine Assurance activities to be carried out by LR will be prepared by LR.



■ *Section 2*

Information to be submitted**2.1 Submarine Safety Management System**

2.1.1 Submarine Safety Management System documentation is to be submitted by the submarine Owner.

2.1.2 With respect to design, procurement, construction, maintenance and operation of the submarine, the documentation is to define:

- (a) Safety Management Policies, processes and procedures including:
 - (i) Maintenance policy, systems and requirements,
 - (ii) Emergency management policy, systems and requirements, and
 - (iii) Audit monitoring and review activities.
- (b) Organisations, organisational structures, roles and responsibilities;
- (c) Concept of operations statement including safe operating boundaries;
- (d) Project specifications;
- (e) Requirements related to Rules, Codes and standards;
- (f) Requirements related to submarine functions and systems;
- (g) Requirements related to configuration control of documentation;
- (h) Requirements related to configuration and control of materials, systems, equipment and components; and
- (i) Process for managing operating restrictions, and non-compliance.

2.2 Submarine Safety Assurance System

2.2.1 Submarine Safety Assurance documentation is to be submitted by the submarine Owner, designer, builder or maintenance organisation as appropriate.

2.2.2 The documentation is to address the full submarine lifecycle or specific lifecycle phases for which Submarine Assurance is required.

2.2.3 With regard to the design, procurement, construction, maintenance and operation of the submarine, the documentation is to define:

- (a) Role of Submarine Safety Assurance within Submarine Safety Management;
- (b) Role of Submarine Assurance by LR within Submarine Safety Assurance;
- (c) Organisations, organisational structures, roles and responsibilities;
- (d) Quality assurance policy, processes and procedures;
- (e) Systems engineering policy, processes and procedures;
- (f) Design, construction, maintenance policies, processes and procedures;
- (g) Safety criticality categorisation policy, processes and procedures for submarine systems, equipment and components;
- (h) Whole Boat Safety Argument including justification of Rules, Codes and standards to be applied;
- (i) Whole Boat and specification requirements including Rules, Codes and standards;
- (j) Work Breakdown Structure for the submarine and its systems; and
- (k) Scope of Submarine Assurance.

2.3 Quality Management Plan

2.3.1 A Quality Management Plan is to be submitted by the submarine designer, builder or maintenance organisation as appropriate.

2.3.2 The plan is to address the full submarine lifecycle or specific lifecycle phases for which Submarine Assurance is required.

2.3.3 The plan is to describe how quality is to be managed during design, construction or maintenance of the submarine.

2.3.4 The plan is to be consistent with and support the Submarine Safety Assurance System.

2.4 Systems Engineering Management Plan

2.4.1 A Systems Engineering Management Plan describing how the design of the submarine will be organised, structured, and carried out is to be submitted by the submarine designer.

2.4.2 The plan is to describe a logical sequence of decision making and design related activities that transforms the operational need into a submarine design.

2.4.3 The plan is to describe an approach to systems engineering that is consistent with established and recognised systems engineering standards.

2.4.4 The plan is to be consistent with and support the Safety Assurance System.

2.4.5 The plan is to include processes for:

- (a) Project management;
- (b) Requirements management;
- (c) System integration;
- (d) Quality management;
- (e) Design management;
- (f) Safety management;
- (g) Risk management;
- (h) Configuration management; and
- (i) Information management.

■ *Section 3*

Submarine assurance planning

3.1 Assurance process

3.1.1 Submarine Assurance planning is to establish and document the scope of the Submarine Assurance activities required to be carried out by LR.

3.1.2 The submarine Owner is to have an appropriate Submarine Safety Management System in place.

3.1.3 The submarine Owner, designer, builder or maintenance organisation is to have an appropriate Submarine Safety Assurance System in place for the lifecycle phase or phases for which Submarine Assurance is required.

3.1.4 The submarine Owner, designer, builder or maintenance organisation is to have an appropriate Quality Management System in place covering the design, construction or maintenance of submarines as appropriate.

3.1.5 The Quality Management System is to be in accordance with a recognised and acceptable international, national or sector standard.

3.1.6 The submarine designer is to have an appropriate Systems Engineering Management System in place for the design of the submarine where Submarine Assurance is required for the design phase of the submarine lifecycle.

3.1.7 The Systems Engineering Management System is to be in accordance with a recognised and acceptable international, national or sector standard.

3.1.8 The assurance activities required to be carried out by LR are to be established based on the Submarine Safety Assurance System in consultation with the submarine Owner, designer, builder or maintenance organisation as appropriate.

3.1.9 A Submarine Assurance Plan will be prepared by LR in consultation with the submarine designer, builder or maintenance organisation.

3.1.10 The plan will define the roles and responsibilities of the entities involved.

3.1.11 The plan will define the scope of activity to be carried out by LR in terms of the Submarine Assurance Framework Goals, Functional Objectives and Performance Requirements within scope, in terms of the submarine systems within scope and in terms of submarine lifecycle phases within scope.

3.1.12 The plan will describe the assurance activities to be carried out by LR in accordance with the submarine systems or in accordance with the submarine Work Breakdown Structure.

3.1.13 The plan is to be agreed by the submarine Owner and Naval Administration.

■ *Section 4*

Documentation to be issued

4.1 Submarine Assurance Plan

4.1.1 The Submarine Assurance Plan will be issued by LR.

4.1.2 The plan will define the Submarine Assurance Framework Goals, Functional Objectives and Performance Requirements within scope, the submarine systems within scope and the submarine lifecycle phases within scope and will establish:

- (a) The scope of verification activities to be carried out during the Standards Justification process to verify that the proposed project specifications, Rules, Codes and standards satisfy the Submarine Assurance Goals, Functional Objectives and Performance Requirements;
- (b) The scope of verification activities to be carried out during the Design Verification process to verify that the design of the submarine satisfies the previously verified project specifications, Rules, Codes and standards; and
- (c) The scope of verification activities to be carried out during the Product Verification process to verify that the construction of the submarine and the manufacturing of products used in the construction of the submarine satisfy the previously verified design and project specifications, Rules, Codes and standards.

Section

- 1 **Objective and scope**
- 2 **Information to be submitted**
- 3 **Standards justification**
- 4 **Documentation to be issued**

■ Section 1 Objective and scope

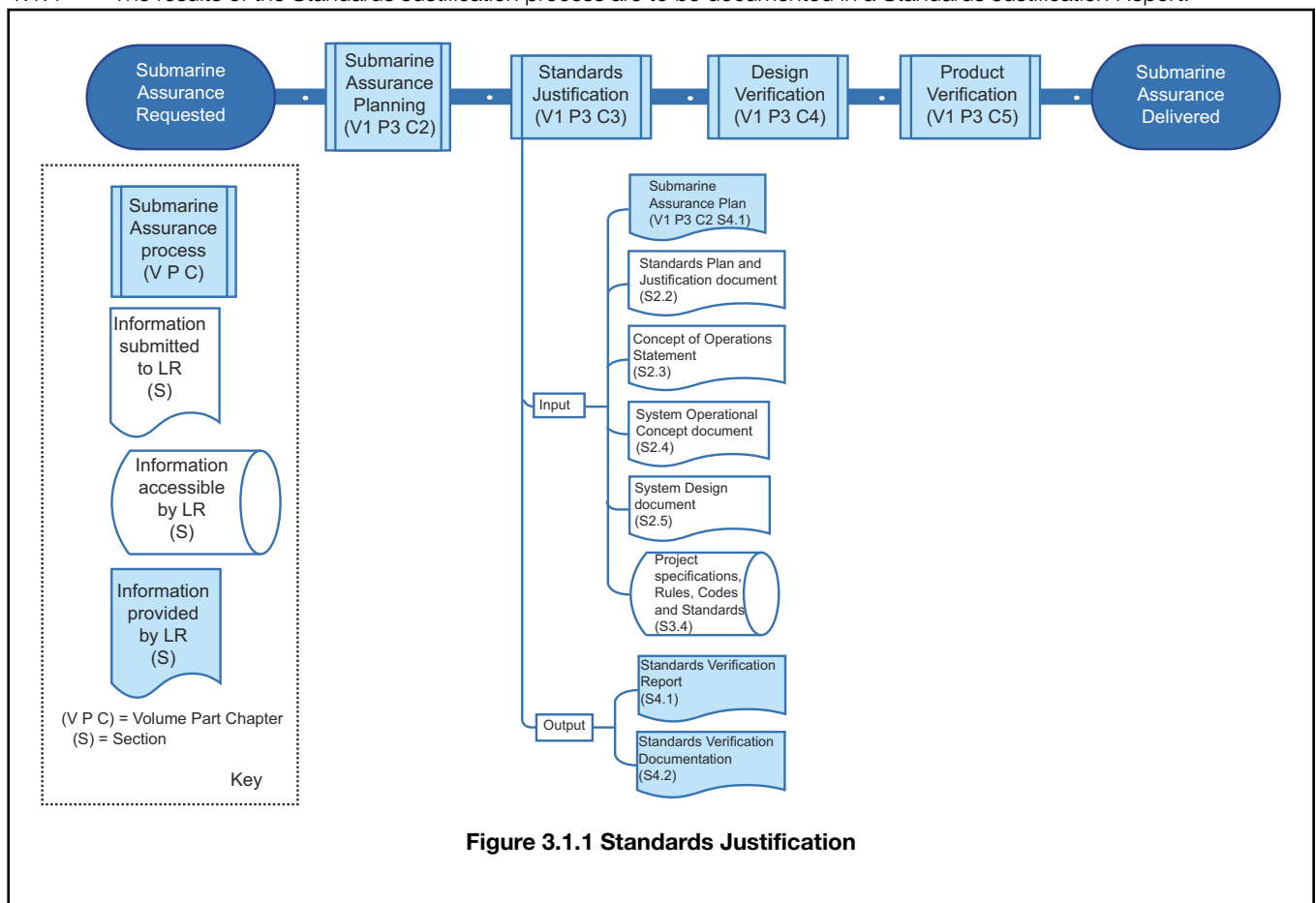
1.1 General

1.1.1 The Standards Justification process considers the justifications provided for the proposed use of project specifications, Rules, Codes and standards and independently assesses their suitability in meeting the Submarine Assurance Framework Goals, Functional Objectives and Performance Requirements.

1.1.2 The scope of verification and the verification activities to be carried out by LR are proposed by the submarine Designer, agreed by LR and detailed in a Standards Plan and Justification Document.

1.1.3 The Standards Plan and Justification Document is considered an integral part of the Submarine Assurance Plan.

1.1.4 The results of the Standards Justification process are to be documented in a Standards Justification Report.



■ *Section 2*

Information to be submitted

2.1 General

2.1.1 In addition to the documentation and information associated with the Submarine Assurance Planning process, the documentation listed in this section is to be submitted.

2.2 Standards Plan and Justification Document

2.2.1 A Standards Plan and Justification Document is to be submitted by the submarine designer.

2.2.2 The plan is to list the Submarine Assurance Framework Goals, Functional Objectives and Performance Requirements in accordance with the intended scope of verification.

2.2.3 The plan is to identify project specifications, Rules Codes and standards, the requirements of which, which when correctly applied, are considered to satisfy relevant framework Performance Requirements and therefore satisfy the corresponding Functional Objectives and Goals of the framework.

2.2.4 For each of the Performance Requirements in scope and the corresponding project specifications, Rules Codes and standards, the plan is to provide a justification for the proposed solution.

2.3 Concept of Operations Statement

2.3.1 A Concept of Operations Statement (ConOpS) is to be submitted by the submarine Owner.

2.3.2 With respect to the submarine, the statement is to list the:

- (a) Particulars;
- (b) Owner;
- (c) Naval Administration;
- (d) Primary and secondary roles;
- (e) Attributes;
- (f) Operational area;
- (g) Operating environment;
- (h) Operating philosophy;
- (i) Survey, maintenance and disposal philosophy; and
- (j) Design life.

2.4 System Operational Concept Document

2.4.1 A System Operational Concept Document is to be submitted by the submarine designer for each system.

2.4.2 The document is to document the system operational concept and provide traceability to the ConOpS and is to describe the design intent and operational requirements for the key submarine systems.

2.4.3 The document will typically include the following systems as appropriate to the scope of verification:

- (a) Structural and watertight integrity;
- (b) Submarine control;
- (c) Manoeuvring;
- (d) Power and propulsion;
- (e) Energy storage, power generation and distribution;
- (f) Ballast, trim and compensation;
- (g) Life-support and protection;
- (h) Munitions storage and handling; and
- (i) Integrated damage control and fire protection.

2.4.4 The document is to include the following information, as appropriate to the system:

-
- (a) System function and performance requirements derived from the ConOpS;
 - (b) Operating modes including abnormal, reversionary and emergency modes recognising the operational and manning philosophy for the submarine;
 - (c) Design intent descriptions;
 - (d) System, equipment and component safety criticality;
 - (e) System, equipment and component dependencies;
 - (f) Performance requirements necessary to maintain submarine functions for normal, abnormal and emergency operating conditions; and
 - (g) Intended Operational envelope.

2.5 System Design Document

2.5.1 A System Design Document is to be submitted by the submarine designer for each system.

2.5.2 The document is to describe the system design and provide traceability to the System Operational Concept document for the systems, sub-components, equipment and is to detail their capability and functionality under normal, abnormal and emergency operating conditions.

2.5.3 The document is to include the following information, as relevant to the system:

- (a) Requirements derived from the System Operational Concept;
 - (b) User interfaces, control and alert arrangements including reversionary and emergency modes recognising the operational and manning philosophy for the submarine;
 - (c) System parameters (capacity, power, discharge rate, etc.);
 - (d) System redundancy;
 - (e) Performance degradation under extreme operating conditions;
 - (f) Components, equipment and sub-systems;
 - (g) The system safety definitions and safety functional requirements;
 - (h) Justification of the selected system architecture; and
 - (i) Design analysis results.
-

■ Section 3 Standards justification

3.1 Assurance process

3.1.1 Standards Justification is to establish that the proposed project specifications, Rules Codes and standards satisfy the Submarine Assurance Framework Performance Requirements and therefore the corresponding Functional Objectives and Goals of the framework and therefore are considered to be acceptable solutions.

3.1.2 The approach to verification of the Standards Plan and Justification Document is to be agreed between the submarine designer and LR prior to any verification activity and in accordance with the Submarine Assurance Plan.

3.1.3 The scope of verification of the Standards Plan and Justification Document to be carried out by LR and the roles of the entities involved are to be in accordance with the Submarine Assurance Plan.

3.1.4 Arrangements for accessing project specifications, Rules Codes and standards are to be provided.

3.1.5 Arrangements for managing non-compliances in accordance with their categorisation are to be agreed. The impact of non-compliances is to be established.

3.1.6 Arrangements for reporting the results of verification activities are to be defined.

3.1.7 Verification is to ensure that solutions for all of the framework Performance Requirements within the scope of Submarine Assurance as defined in the Submarine Assurance Plan are identified.

3.1.8 Verification is to ensure that solutions fully satisfy the framework Performance Requirements for both specific submarine system Performance Requirements and Whole Boat Performance Requirements.

3.1.9 Verification is to ensure that solutions are consistent with the ConOpS, the System Operational Concept, the System Design Description and where available, the Operational envelope for the submarine.

3.1.10 Verification is to ensure that solutions are sufficiently justified and supported by documented evidence, e.g. analysis, simulation, testing, in-service experience etc.

3.1.11 Where in-service experience is proposed as evidence of suitability, the in-service experience is to be sufficiently representative and include operation under normal, abnormal and emergency operating conditions.

■ *Section 4*

Documentation to be issued

4.1 Standards Justification Report

4.1.1 A Standards Justification Report will be used by LR. The report will detail the justification results and include details of non-compliance with performance requirements and missing or conflicting solutions.

4.2 Standards justification documentation

4.2.1 Justification documentation will be issued by LR to identify the Goals, Functional Objectives and Performance Requirements which have been satisfactorily justified with reference the Standards Plan and Justification document.

Section

- 1 **Objective and scope**
 - 2 **Information to be submitted**
 - 3 **Design verification**
 - 4 **Documentation to be issued**
-

■ *Section 1*
Objective and scope

1.1 General

1.1.1 The Design Verification process assesses the design of the submarine for compliance with the applicable project specifications, Rules, Codes and standards.

1.1.2 The scope of verification and the verification activities to be carried out by LR are proposed by the submarine designer, agreed by LR and detailed in a Design Verification Plan.

1.1.3 The Design Verification plan is considered an integral part of the Submarine Assurance Plan.

1.1.4 The results of the Design Verification process are to be documented in a Design Verification Report.

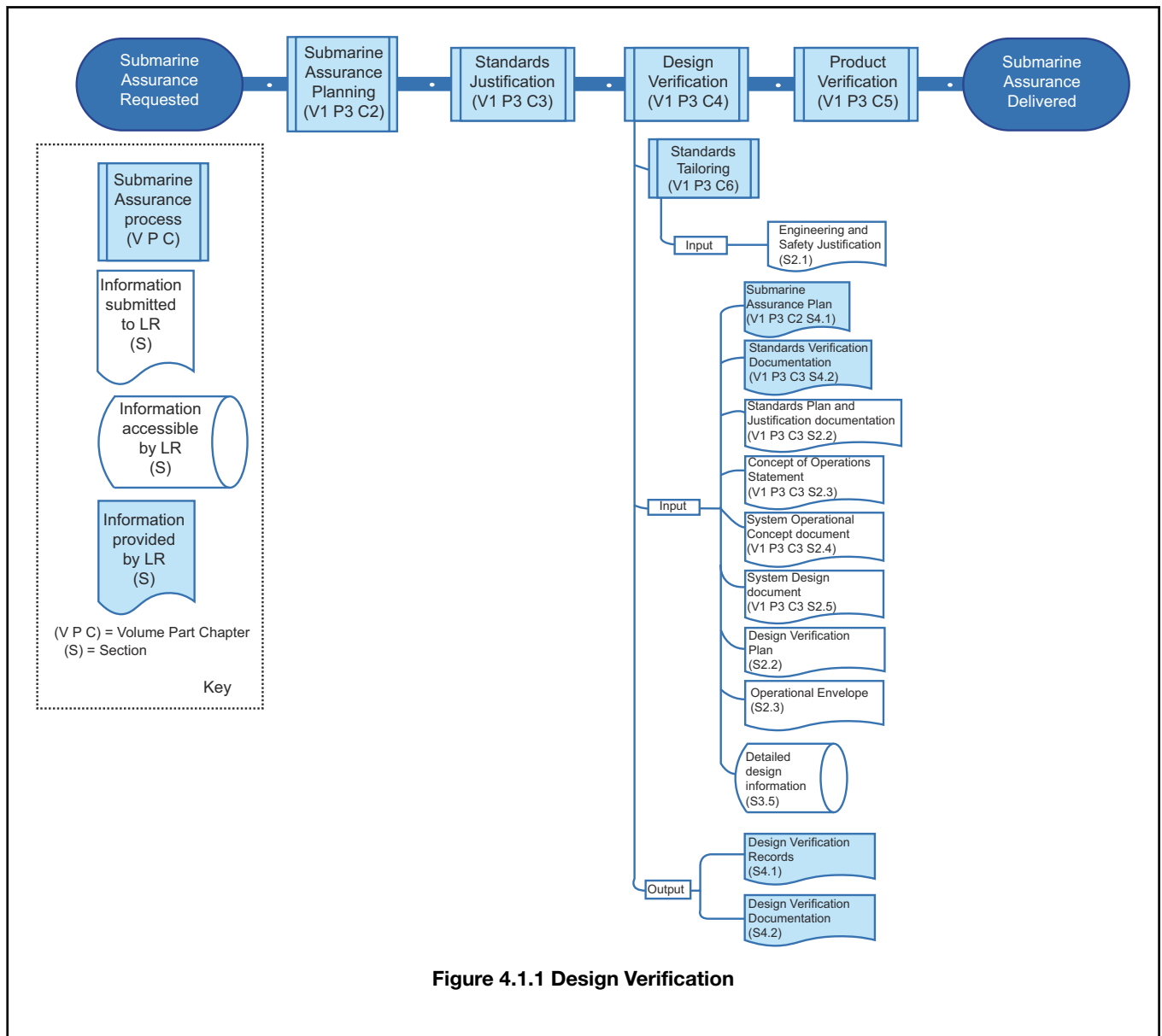


Figure 4.1.1 Design Verification

Section 2

Information to be submitted

2.1 General

2.1.1 In addition to the documentation and information associated with the Submarine Assurance Planning and Standards Justification processes, the documentation listed in this section is to be submitted.

2.2 Design Verification Plan

2.2.1 The Design Verification (DV) Plan is to be submitted by the submarine designer.

2.2.2 The plan is to identify the systems, equipment and components within the scope of verification defined in the Submarine Assurance Plan.

2.2.3 The plan is to provide a mapping of the systems, equipment and components within scope to the applicable project specifications, Rules, codes or standards and the corresponding design documentation to be used for verification.

2.2.4 The plan is to take account of the operating context for the systems, equipment and components as defined System Operational Concept documentation.

2.2.5 The plan is to define Whole Boat requirements to be taken into account during verification of the design.

2.2.6 The plan is to indicate the safety criticality category of the submarine system, equipment or components to be verified in accordance with the safety criticality defined in the System Operational Concept Document.

2.2.7 The plan is to include details of:

- (a) Systems, equipment and components for which Design Verification is to be carried out;
- (b) Project specifications, Rules, Codes and standards to be verified;
- (c) Means of design verification to be carried out, e.g. design review, modelling, testing etc.;
- (d) Interfaces with submarine systems outside of scope;
- (e) Additional specification requirements;
- (f) Applicable Whole Boat requirements; and
- (g) Any deviations with proposed equivalents or alternatives.

2.2.8 The plan is to describe the specific types of verification activities to be undertaken, e.g. Internal Review, Design Review, Design Audit, Design Appraisal, Independent Analysis, Modelling, Testing or assessment of in-service experience.

2.3 Operational envelope

2.3.1 An Operational envelope is to be submitted by the submarine designer.

2.3.2 The document is to define the capability of the submarine, systems, equipment and components. The information is to enable safe operation of the submarine and adequately define design, build and operational constraints.

2.3.3 The Operational envelope is to be defined for the following submarine operating modes, consistent with the submarine ConOpS:

- (a) Surface;
- (b) Dived;
- (c) Periscope depth;
- (d) Near surface constant depth operating conditions;
- (e) Anchor;
- (f) Towing operations;
- (g) Berthing;
- (h) Docking;
- (i) Distressed submarine;
- (j) Trials;
- (k) Maintenance periods;
- (l) Hot lay-up, manned;
- (m) Cold lay-up, unmanned;
- (n) Under tow; and
- (o) Transit on another vehicle or structure.

2.3.4 The Operational Envelope is to be provided with limits for, for normal, abnormal and emergency operating conditions.

2.3.5 The Operational envelope is to be provided at the end of the design phase, updated following construction and maintained through the life of the submarine.

■ *Section 3* **Design verification**

3.1 Assurance process

3.1.1 Design Verification is to establish that the design of the submarine satisfies the applicable project specifications, Rules, Codes and standards previously verified and considered acceptable solutions during Standards Justification.

3.1.2 The approach to verification documented in the Design Verification Plan is to be agreed between the submarine designer and LR prior to any verification activity and in accordance with the Submarine Assurance Plan.

3.1.3 The scope of verification to be carried out by LR and the roles of the entities involved is to be in accordance with the Submarine Assurance Plan.

3.1.4 Arrangements for accessing design related information and allowing comparison between the design related information and documentation and the project specifications, Rules Codes and standards are to be provided.

3.1.5 Arrangements for verification of the Operational envelope following design and prior to construction of the submarine and following construction of the submarine are to be agreed.

3.1.6 Arrangements for managing non-compliances in accordance with their categorisation are to be agreed. The impact of non-compliances is to be established.

3.1.7 Arrangements for reporting the results of verification activities are to be defined.

3.1.8 Verification is to confirm that the Design Verification Plan is consistent with the Standards Plan and Justification Document following any revision necessary as a result of the Standards Verification process.

3.1.9 Verification is to confirm that the design of the submarine satisfies the applicable project specifications, Rules, Codes and standards previously verified and considered acceptable solutions during Standards Justification.

3.1.10 Verification is to be carried out at key stages in the design of the submarine including Concept Design, Initial Design and Detailed Design as appropriate and is to include review of the following information as appropriate:

- (a) Technical documentation describing the design of the submarine;
- (b) Systems engineering policy, processes and application;
- (c) Human factors policy, processes and application;
- (d) Design and manufacturing policy and processes and application;
- (e) Quality assurance policy, processes and application;
- (f) Transverse requirements;
- (g) Hazard identification and risk assessment studies;
- (h) Engineering and safety justifications; and
- (i) Calculations, analyses, modelling and testing reports.

3.1.11 Review of information is to establish that:

- (a) Organisations carrying out calculations, analyses, modelling or testing are competent;
- (b) Scope of calculation, analysis, modelling or testing is sufficient;
- (c) Assumptions made in the calculations, analyses, modelling or testing are valid;
- (d) Design constraints are adequately defined and assessed;
- (e) Calculation, analyses, modelling or testing is appropriate and of sufficient depth and rigor;
- (f) Calculation, analyses or modelling tools have been validated;
- (g) Testing equipment is calibrated;
- (h) Results and analysis are appropriately recorded; and
- (i) Analyses, calculation, modelling or test results are reasonable.

3.1.12 Verification is to confirm that appropriate requirements have been established for system, equipment and component; reliability, availability and maintainability.

3.1.13 Verification is to take account of relevant hazard assessment and risk assessment studies.

3.1.14 Verification is to take account of Whole Boat requirements.

3.1.15 Verification activities are to be appropriate for the safety criticality category of the submarine system, equipment or component.

3.1.16 Verification activities are to include a combination of Internal Review, Design Review, Design Audit, Design Appraisal, Independent Analysis, Modelling, Testing or assessment of relevant in-service experience.

3.1.17 Where in-service experience is proposed as evidence of suitability, the in-service experience is to be sufficiently representative and include operation under normal, abnormal and emergency operating conditions.

3.1.18 Revisions to the design are to be controlled and assessed for their impact on on-going or scheduled verification activities. On-going or scheduled verification activities are to be revised where necessary in accordance with the requirements of the Design Verification Plan.

3.1.19 LR is to be advised of modifications undertaken during the design of the submarine. Design modifications are to be evaluated for any impact on the System Design Description, the System Operational Concept and ultimately the Concept of Operations. The Design Verification Plan and where appropriate the Submarine Assurance Plan are to be updated and re-verification carried out as necessary.

3.1.20 Verification is to confirm that the submarine Operational envelope correctly reflects operating constraints.

■ *Section 4*

Documentation to be issued

4.1 Design verification records

4.1.1 Design verification records will be issued by LR. The records will identify the verification activities carried out in accordance with the Design Verification Plan and the results thereof.

4.1.2 The records will reference the documentation reviewed and include any agreed deviations from the justified project specifications, Rules, Codes and standards in the form of equivalents or exemptions.

4.1.3 The records will record the design basis, the verified configuration and the verification results in sufficient detail to support future review, modification or reassessment.

4.2 Design verification documentation

4.2.1 Verification documentation will be issued by LR to confirm compliance with the verification requirements defined in the Design verification Plan and identify any non-compliances.

Section

- 1 **Objective and scope**
 - 2 **Information to be submitted**
 - 3 **Product verification**
 - 4 **Documentation to be issue**
-

■ *Section 1*
Objective and scope

1.1 General

1.1.1 The Product Verification process assesses the construction of the submarine and its systems, equipment and components for compliance with the applicable project specifications, Rules, Codes and standards and the design previously verified during Design Verification.

1.1.2 The scope of verification and the verification activities to be carried out by LR are proposed by the submarine builder, agreed by LR and detailed in a Product Verification Plan.

1.1.3 The Product Verification plan forms an integral part of the Submarine Assurance Plan.

1.1.4 The results of the Product Verification process are to be documented in a Product Verification Report.

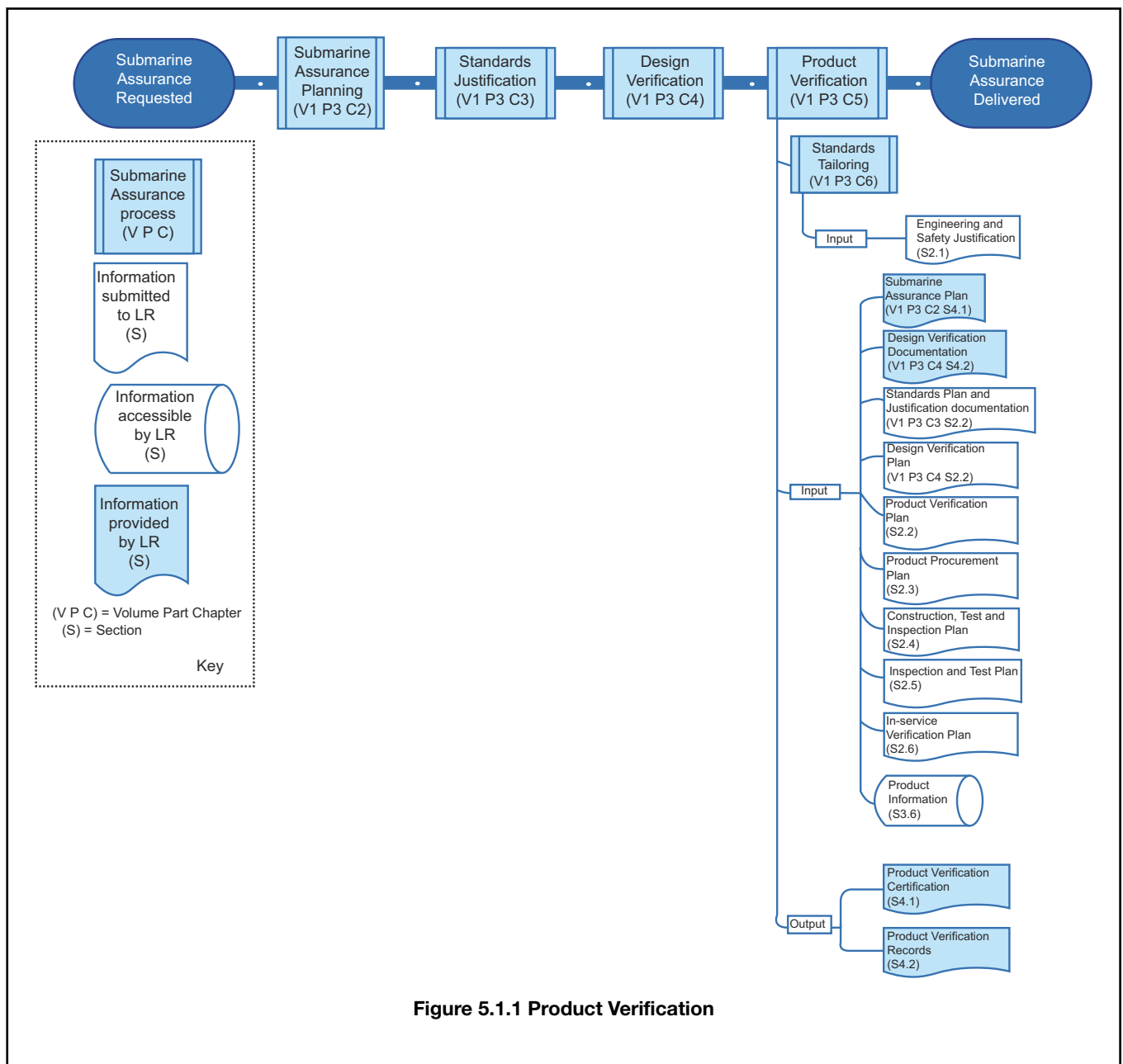


Figure 5.1.1 Product Verification

Section 2

Information to be submitted

2.1 General

2.1.1 In addition to the documentation and information associated with the Submarine Assurance Planning, Standards Justification and Design Verification processes, the documentation listed in this section is to be submitted.

2.2 Product Verification Plan

2.2.1 A Product Verification (PV) Plan is to be submitted by the submarine builder.

2.2.2 The plan is to detail the product verification requirements for procured products to be used in the construction of the submarine based on the scope of verification defined in the Submarine Assurance Plan.

2.2.3 The plan is to provide a mapping of the products and the applicable project specifications, Rules, Codes or standards.

2.2.4 The plan is to include separate plans defining the verification activities required to be carried during manufacturing of the products at the product manufacturers works and the verification activities required to be carried out during and following integration of the products at the submarine construction site.

2.2.5 The plan is to indicate the safety criticality category of the submarine system, equipment or components to be verified in accordance with the safety criticality defined in the System Operational Concept Document.

2.2.6 The plan is to separately define any additional assurance requirements not related to the safety criticality category which may be derived from production, client or other stakeholder requirements.

2.2.7 The plan is to identify any quality schemes applied for the verification of submarine systems, equipment or components.

2.3 Product Procurement Plan

2.3.1 A Product Procurement Plan is to be submitted by the submarine builder.

2.3.2 The plan is to identify the procured products within the scope of verification during product manufacturing.

2.3.3 The plan is to identify product manufacturers and their sub-suppliers to an appropriate level of granularity for verification activities to be defined.

2.4 Construction, Test and Inspection Plan

2.4.1 A Construction, Test and Inspection (CTI) Plan is to be submitted by the submarine builder.

2.4.2 The plan is to detail the product verification requirements for the submarine systems based on the scope of verification defined in the Product Verification Plan.

2.4.3 The plan is to define the program of inspection, testing and survey required to be carried out by LR during and following integration of the products at the submarine construction site.

2.4.4 The plan is to provide a mapping of the systems in scope, the applicable project specifications, Rules, Codes or standards and the product verification requirements.

2.4.5 The plan is to indicate the safety criticality categorisation of the systems, equipment and components in accordance with the safety criticality defined in the System Operational Concept Document.

2.4.6 The plan is to indicate the type of verification activity to be carried out and indicate where the process hold points are and what certificates are required to continue.

2.4.7 The plan is to list construction processes subject to verification activities and the frequency thereof.

2.4.8 The plan is to include the verification requirements for:

- (a) Incoming product inspection including materials;
- (b) Fabrication survey and inspection;
- (c) Process audit and review;
- (d) Survey and inspection during installation;
- (e) Integration and testing; and
- (f) Trials.

2.4.9 The plan and the verification activities therein are to be agreed by LR.

2.5 Inspection and Test Plan

2.5.1 An Inspection and Test Plan (ITP) is to be submitted by the submarine builder with information provided by the manufacturer.

2.5.2 A plan is to be developed for each procured product in accordance with the scope of verification defined in the Product Verification Plan.

2.5.3 The plan is to define the program of inspection, testing and survey required to be carried out or witnessed by LR during manufacturing of the products at the product manufacturers works.

2.5.4 The plan is to include the applicable project specifications, Rules, Codes or standards and the product verification requirements.

2.5.5 The plan is to include details of:

- (a) Product identification;
- (b) Component or equipment safety criticality;
- (c) Reference to product specifications and design documentation;
- (d) Manufacturing processes;
- (e) Special manufacturing processes and enhanced verification requirements Materials details and certification requirements;
- (f) Specific verification activities (hold, witness, review and audit);
- (g) Monitoring activities (Patrols and process audit);
- (h) Acceptance criteria and responsible entity;
- (i) Product and prototype testing requirements; and
- (j) Relevant certification.

2.5.6 The plan and the verification activities therein are to be agreed by LR.

2.6 In-service Verification Plan

2.6.1 An In-service Verification (ISV) Plan is to be submitted by the submarine maintenance organisation.

2.6.2 The plan is to detail the verification requirements for the submarine systems based on the scope of verification defined in the Submarine Assurance.

2.6.3 The plan is to provide a mapping of the systems in scope to the applicable project specifications, Rules, Codes or standards and documentation which describes the approved arrangements.

2.6.4 The plan is to indicate the safety criticality categorisation of the systems, equipment and components.

2.6.5 The plan is to define the frequency of verification activities to be carried out by LR and be informed by the survey, inspection and test requirements defined by the submarine builder for the systems, equipment or components.

2.6.6 The plan is to indicate the type of verification activity to be carried out and indicate process hold points, tests, measurements and records.

2.6.7 The plan is to list maintenance activities subject to verification activities.

2.6.8 The plan is to include the verification requirements for:

- (a) Maintenance or testing process audit and review.
- (b) Condition assessment and survey
- (c) Survey and inspection during maintenance.
- (d) Measurements, tests; and
- (e) Trials.

2.6.9 The plan and the verification activities therein are to be agreed by LR.

2.7 Through-life Maintenance Plan

2.7.1 A Through-life Maintenance Plan is to be submitted by the submarine builder or operator. for the systems, equipment and components within the scope of verification.

2.7.2 The plan is to identify safety criticality categorisation, service and inspection intervals.

Section 3 **Product verification**

3.1 Assurance process

3.1.1 Product Verification is to establish that the construction of the submarine and the products procured for the construction of the submarine comply with the applicable project specifications, Rules, Codes and standards previously verified during Standards Justification.

-
- 3.1.2 The approach to verification documented in the Product Verification Plan is to be agreed between the submarine builder and LR prior to any verification activity and in accordance with the Submarine Assurance Plan.
- 3.1.3 Prior to verification, details of the builders and product manufacturers systems for quality and process management are to be provided which readily identify the required verification activities that provide Product Verification.
- 3.1.4 The scope of verification to be carried out by LR and the roles of the entities involved is to be in accordance with the Submarine Assurance Plan.
- 3.1.5 Verification activities are to include a combination of: Works approval, survey of materials, Inspection, survey of production, Document Review, Installation Survey, witness of Testing and Trials in a documented process.
- 3.1.6 Arrangements for accessing product related information and documentation and allowing comparison between the design, construction and product related information and documentation and the project specifications, Rules Codes and standards are to be provided.
- 3.1.7 Arrangements for reporting the results of verification activities are to be defined. Consideration is to be given to the impact on current and proposed verification activities.
- 3.1.8 Verification is to confirm that the Product Verification Plan is consistent with the Standards Plan and Justification Document and the Design Verification Plan following any revision necessary as a result of the Standards Justification and the Design Verification processes respectively.
- 3.1.9 Verification is to confirm that the construction of the submarine and the manufacturing of products procured for the construction of the submarine comply with an approved design previously verified and during Design Verification.
- 3.1.10 Verification is to confirm that the construction of the submarine and the manufacturing of products procured for the construction of the submarine comply with the applicable project specifications, Rules, Codes and standards previously verified and considered acceptable solutions during Standards Justification.
- 3.1.11 Verification is to confirm that the submarine construction and product manufacturing process are appropriate for the materials used and do not reduce the material properties below allowable limits.
- 3.1.12 Verification is to confirm that quality controls used are appropriate for the manufacturing processes, materials used and in accordance with the project specifications, Rules, Codes and standards.
- 3.1.13 Verification is to take account of Whole Boat requirements.
- 3.1.14 Verification activities are to be appropriate for the safety criticality category of the submarine system, equipment or component.
- 3.1.15 Verification is to confirm that adequate processes are in place for the traceability of materials and components appropriate to the safety criticality category.
- 3.1.16 Verification is to confirm that materials and workmanship for the construction of the submarine and the products procured for the construction of the submarine are of suitable quality and free from defects.
- 3.1.17 Arrangements for managing non-compliances in accordance with their categorisation are to be agreed.
- 3.1.18 LR will notify the submarine builder or product manufacturer of any non-conformances at the earliest opportunity.
- 3.1.19 Verification is to confirm that a change control system to assess the impact of change on design, to manage the verification of change and inclusion of change into the build of the submarine.
- 3.1.20 LR is to be advised of any non-compliance identified during the construction of the submarine or product manufacturing. The impact of non-compliances is to be established. Proposed repairs or modifications are to be considered for their impact on the design before they are undertaken.
- 3.1.21 Significant repairs and modifications and any consequential operating constraints are to be agreed by LR, the Navy and the Naval Administration. Repairs and modifications are to be recorded in the product verification report. The Submarine Assurance Plan is to be updated and re-verification carried out as necessary.
- 3.1.22 Objective Quality Evidence to demonstrate compliance at key stages of manufacture and construction is to be established and retained by the submarine builder and product manufacturer. It shall evidence the as built material state of the submarine, system, equipment or component, including non-compliances.

3.2 Product verification during submarine construction

3.2.1 Verification carried out by LR during submarine construction is to confirm that materials and workmanship for the construction of the submarine systems, equipment and components are of suitable quality, free from defects and in accordance with applicable project specifications, Rules, Codes and Standards and applicable processes.

3.2.2 The approach to verification during construction and documented in the construction test and inspection plan is to be agreed between the submarine builder and LR prior to any verification activity and in accordance with the Product Verification Plan.

3.2.3 Prior to the start of construction, the submarine construction facilities are to be inspected and construction processes audited, to confirm that they are considered acceptable by LR for submarine construction. Where construction is transferred to other locations or there is a change in management and organisation, the new arrangements shall also be confirmed as acceptable by LR for submarine construction.

3.2.4 The submarine builder is to identify key steps during submarine construction where verification is to be carried out by LR and the record and supporting evidence to be provided.

3.2.5 LR will notify the submarine builder of any issues identified during verification and where necessary an enhanced level of patrolling and inspection is to be agreed between the builder and LR.

3.2.6 LR will confirm compliance with the agreed verification requirements on completion at the construction milestones.

3.2.7 A progressive programme of component, equipment, system integration and submarine testing is to be established to confirm compliance with the applicable project specifications, Rules, Codes and standards.

3.2.8 The submarine builder is to advise LR of any revision of the Operational Envelope during construction of the submarine and arrangements are to be agreed for re-verification of the Operational envelope through the Design Verification process.

3.3 Product verification during product manufacturing

3.3.1 Verification carried out by LR during product manufacturing is to confirm that materials and workmanship for the product are of suitable quality, free from defects and in accordance with applicable project specifications, Rules, Codes and standards and applicable product manufacturing and quality assurance processes.

3.3.2 The approach to verification during product manufacturing is to be agreed between the submarine builder and LR prior to any verification activity and reflected in the Inspection and Test Plan ITP.

3.3.3 Prior to manufacture, the product manufacturing facilities are to be subject to LR works approval or audit by LR, depending on the safety criticality category. The manufacturing processes is to be demonstrated as being suitable for the products manufactured. Where manufacturing is transferred to other locations or there is a change in management and organisation, the new arrangements shall also be confirmed as acceptable by LR.

3.3.4 The submarine Builder is responsible for all verification activities relating the product manufacturing supply chain. However, subject to special consideration and agreement by all stakeholders, LR may consider direct engagement with product manufacturers for the verification of products. Any such arrangements are to be documented in the Product Verification Plan.

3.3.5 The submarine builder is to identify key steps during product manufacturing where verification is to be carried out by LR and the records and supporting evidence to be provided.

3.3.6 The submarine builder is responsible for communicating with the product manufacturers. Requirements relating to the verification activities are to be carried out by LR.

3.3.7 The submarine builder is to ensure that product manufacturers are provided with accurate and timely details of the arrangements for verification activities to be carried out by LR. However, subject to special consideration, LR will consider direct engagement with product manufacturers for the arrangement of verification activities. Any such arrangements are to be documented in the Product Verification Plan.

3.3.8 LR will notify the product manufacturer and submarine builder of any issues identified during verification and where necessary an enhanced level of patrolling and inspection is to be agreed between the submarine builder, product manufacturer and LR.

3.3.9 LR will record defects, anomalies and deviations as a non-compliance and will notify the submarine builder and product manufacturer at the earliest opportunity.

3.3.10 Repairs undertaken during the product manufacturing are to be recorded in the product verification report. The Product Assurance Plan is to be updated and re-verification carried out as necessary.

3.4 Product verification in-service and during maintenance

- 3.4.1 Verification carried out by LR in-service and during maintenance is to be in accordance with the In-Service Verification plan.
- 3.4.2 Verification carried out by LR in-service and during maintenance, is to confirm that materials and workmanship for the maintenance of the submarine are of suitable quality, free from defects and in accordance with applicable project specifications, Rules, Codes and standards and applicable maintenance and quality assurance processes.
- 3.4.3 LR will maintain records of the verification activities performed.
- 3.4.4 Verification is to confirm that the required maintenance has been carried out in accordance with the Product Maintenance Plan for the systems, equipment and components within the scope of the In-Service Verification plan.
- 3.4.5 Verification is to confirm that the examination and re-validation activities required for systems, equipment and components have been completed.
- 3.4.6 Verification is to confirm that documentation relating to design and operation has been updated to recognise any products replaced, added or repaired as necessary in accordance with change control and configuration control processes.
- 3.4.7 Products replaced, added or repaired are to be subject to Product Verification.
- 3.4.8 Repairs are to be recorded and the re-verification carried out as necessary.
-

■ *Section 4*
Documentation to be issue

4.1 Product verification certification

- 4.1.1 Product verification certification will be issued by LR.
- 4.1.2 The certification will confirm compliance with the verification requirements defined in the ITP.
- 4.1.3 The certification will reference the product documentation, describing the material state together with any non-compliances.

4.2 Product verification records

- 4.2.1 The records issued by LR will identify the verification activities carried out in accordance with the Product Verification Plan and the results thereof.
- 4.2.2 The records will confirm compliance with the product verification requirements defined in the ITP.
- 4.2.3 The records will indicate any non-compliances.
- 4.2.4 The records will include or reference Objective Quality Evidence.

Section

- 1 Objective and scope**
 - 2 Information to be submitted**
 - 3 Tailoring of Rules, Codes and Standards**
 - 4 Documentation to be issued**
-

■ *Section 1*
Objective and scope

1.1 General

- 1.1.1 The Tailoring process assesses any proposed deviations from the requirements of the applicable project specifications, Rules, Codes and standards and ensures they are fully justified and agreed.
- 1.1.2 The deviation may be proposed by the submarine Owner, designer, builder or maintenance organisation as appropriate.
- 1.1.3 The justification is provided by the proposer and forms part of the Submarine Assurance Plan.

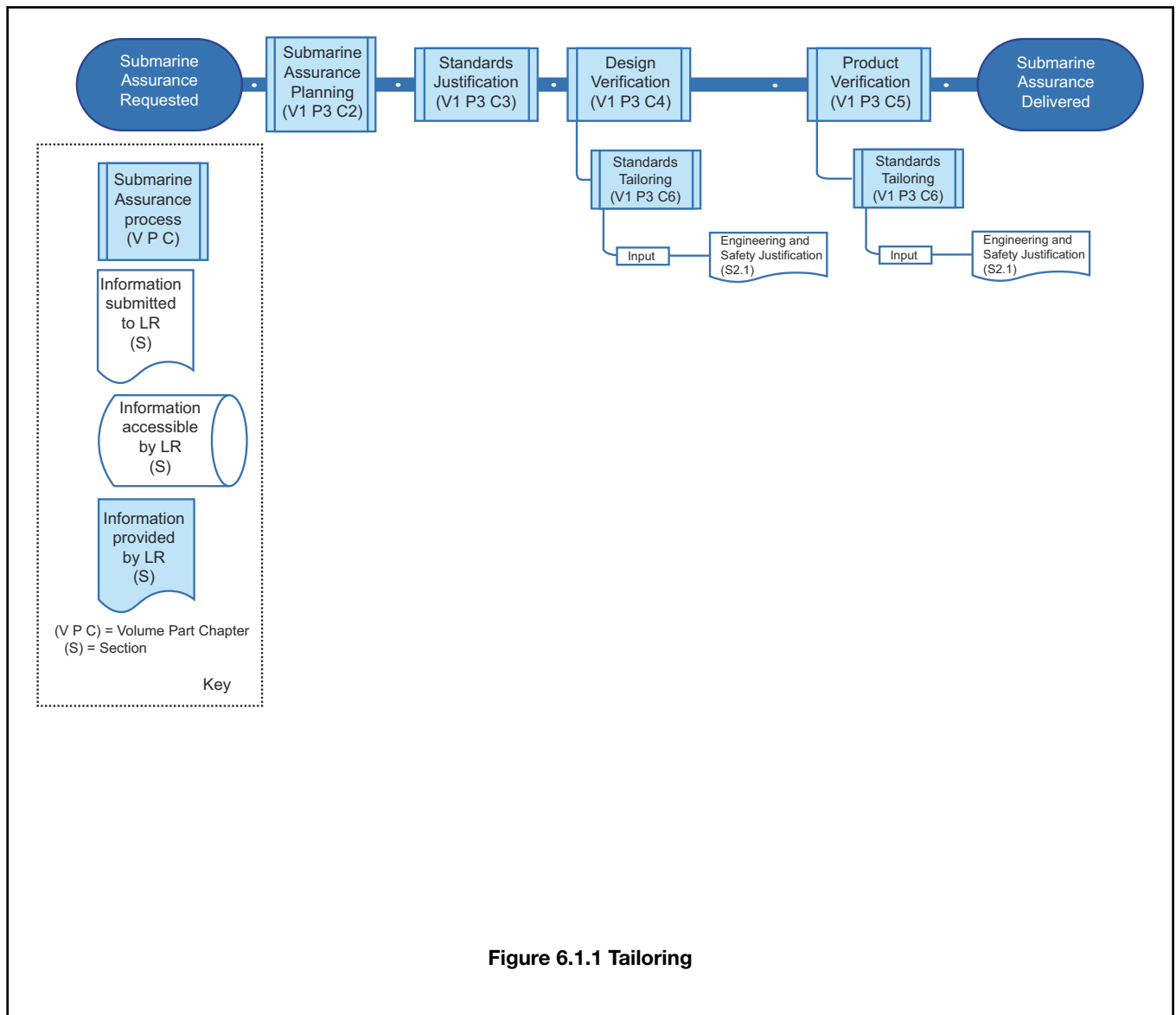


Figure 6.1.1 Tailoring

Section 2

Information to be submitted

2.1 Engineering and safety justification

2.1.1 An Engineering and Safety Justification is to be submitted by the submarine Owner, designer, builder or maintenance organisation.

2.1.2 The justification is to identify each non-compliance and is to describe the proposed Equivalent or Alternative solution.

2.1.3 With respect to the Equivalent or Alternative Solution, the justification is to detail:

- (a) Operating parameters and any required limitations;
- (b) Installation arrangements;
- (c) Details of life-limited critical components;
- (d) Potential functional failures that could lead to hazardous consequences and/or degradation in systems performance and mitigations;

-
- (e) Potential internal failures that could lead to hazardous consequences and/or degradation in systems performance and mitigations;
 - (f) Common mode failures and mitigations;
 - (g) Single point failures and mitigations; and
 - (h) Impact of failures on the wider system.
-

Section 3 **Tailoring of Rules, Codes and Standards**

3.1 Tailoring process

3.1.1 The Tailoring process considers non-compliance from the requirements prescribed in the justified Rules, Codes or standards based on an appropriate justification where full compliance cannot be achieved.

3.1.2 Tailoring is not intended to be applied to the Goal based requirements of the Submarine Assurance Framework which, by definition, facilitate a range of different solutions, but is intended to be applied at the Design Verification and Product Verification level where specific requirements of the justified Rules, Codes and standards cannot be satisfied.

3.1.3 Intended non-compliances with the requirements of Rules, Codes and standards are to be categorised as to whether they are considered to provide an Equivalent solution, an Alternative solution, or require an Exemption.

3.1.4 Any clarification in the applicability of an individual requirement within the Rules, Codes and standards is defined as an Interpretation and, although not considered to be a non-compliance, the requirement together with the interpretation and the rationale for the interpretation are to be documented and agreed by LR.

3.1.5 Non-compliance with individual requirements within the Rules, Codes and standards, which are considered to provide equivalence to the intent of the prescribed requirements, are considered to provide an Equivalent solution.

3.1.6 Non-compliance with multiple related requirements within the Rules, Codes and standards or from the Rules, Codes and standards themselves, which are considered to provide for an alternative to those requirements, are considered to provide an Alternative solution.

3.1.7 Equivalent and Alternative solutions are to be identified by the submarine designer or builder and supported by a dedicated Engineering and Safety Justification.

3.1.8 The Engineering and Safety Justification is to provide a reasoned and compelling argument supported by a suitable body of evidence that the Equivalent or Alternative solution proposed is an acceptable equivalent or alternative to that prescribed by the Rules, Codes and standards.

3.1.9 The Engineering and Safety Justification is to include details of the safety implications associated with the Equivalent or Alternative solution and the control measures to be implemented to mitigate any risks associated with the Equivalent or Alternative solution.

3.1.10 The Engineering and Safety Justification is to consider the operating context, including normal abnormal and emergency operating conditions.

3.1.11 Depending upon the potential impact of the non-compliance, the Engineering and Safety Justification may be required to include a formal risk assessment.

3.1.12 All non-compliances are to be agreed by LR, the Owner and the Naval Administration. Where LR does not agree that a deviation from the Rules, Codes or standards is appropriate, LR will require the Board of the Naval Administration to provide a written Exemption.

3.1.13 Agreed Alternative Solutions are to be included in the Standards Justification process and verified as part of the Design Verification process and/or Product Verification process as appropriate.

■ *Section 4***Documentation to be issued****4.1 Tailoring output**

4.1.1 Agreed Equivalent solutions are to be recorded in the Design Verification Records or Product Verification Records as appropriate.

4.1.2 Agreed Alternative solutions are to be recorded in the Standards Justification Plan and the Design Verification Plan or Product Verification Plans as appropriate.

Section

1 Terms, definitions and acronyms related to Part 3

■ Section 1 Terms, definitions and acronyms related to Part 3

1.1 Definitions

1.1.1 The following terms and definitions are relevant:

- **Interpretation.** Clarification regarding the application of an individual requirement within the Project specifications, Rules, Codes and standards to the design. Interpretations including the requirement together with the interpretation and the rationale for the interpretation are to be documented by the designer and agreed by LR.
- **Non-compliance.** Intended or unintended deviations from the Project specifications, Rules Codes and standards. Categories of non-compliance are:
 - **Equivalent Solution.** Intended non-compliance with individual requirements within the Project specifications, Rules, Codes and standards which are considered to provide equivalence to the intent of the prescribed requirements. To be prepared by the designer and agreed with LR, and Naval Administration.
 - **Alternative Solution.** Intended non-compliance with multiple related requirements within the Project specifications, Rules, Codes and standards which are considered to provide an alternative to those requirements. To be prepared by the designer and agreed with LR, Navy and Naval Administration.
 - **Exemption.** Intended non-compliance with the requirements within the Project specifications, Rules, Codes and standards which are not considered by LR to provide an acceptable equivalent or alternative arrangements. To be prepared by the designer and agreed with the Navy and Naval Administration.
 - **Defect.** Unintended non-compliance with Project specifications, Rules, Codes and standards which is to be assessed for the impact on the design. Rectification or retention of the defect is to be proposed and justified by the designer and agreed with LR, Navy and Naval Administration.
- **Objective Quality Evidence.** A record which demonstrates the quality of a product based on physical measurements, observations or tests which have been appropriately verified. The record and evidence are to demonstrate compliance with projects specifications, Rules, Codes and standards and are to include sufficient information to support future verification activities.
- **Operating constraint.** Constraints on the operation of the submarine imposed as a result of defects in design or build that affect the submarine Operational envelope. To be prepared by the designer and agreed with LR, Navy and Naval Administration and reflected in the submarine Operational envelope.
- **Solution.** Project specifications, Rules Codes and standards, the requirements of which, which when correctly applied, are considered to satisfy framework Performance Requirements and therefore the corresponding Functional Objectives and Goals of the framework.

1.2 Acronyms

1.2.1 The following Acronyms are relevant:

- **CTI.** Construction, Test and Inspection
- **ITP.** Inspection and Test Plan
- **PVP.** Product Verification Plan

Section

- 1 **Framework goals explained**
- 2 **Framework functional objectives explained**
- 3 **Performance requirements explained**

■ *Section 1* **Framework goals explained**

1.1 Framework structure

1.1.1 The Submarine Assurance Framework structure consists of a hierarchy in which lower-level tiers support upper tiers.

1.1.2 For each subject or major hazard covered by a part of the Submarine Assurance Framework, such as Fire Safety, a succinct goal is established. For example, the goal for fire safety may include the statement 'The submarine, arrangements, shall be designed, constructed and maintained in such a way that the fire can be prevented, detected, contained and extinguished so that essential safety functions can be maintained'.

■ *Section 2* **Framework functional objectives explained**

2.1 Functional objectives

2.1.1 Functional objectives are defined to provide a structure to the parts of the Submarine Assurance Framework so that relevant requirements and acceptance criteria can be captured. They subdivide a Goal into manageable elements, the subdivision may be based on a logical flow, system breakdown, or process steps. Typically, functional objectives are associated with Chapters of the Submarine Assurance Framework. An example of a functional objective might be 'fire protection boundaries'. Functional Objectives are equivalent to Tier 2 of the NSubC.

■ *Section 3* **Performance requirements explained**

3.1 Performance requirements

3.1.1 The performance requirements for each functional objective are listed, for example 'divisions formed by bulkheads and decks are to prevent the passage of fire and smoke'. The performance requirements are independent of the technical or operational solution and have a qualitative character. Performance Requirements are equivalent to Tier 3 of the NSubC.

Section

- 1 **Scope**
- 2 **Goals**
- 3 **General functional objectives**
- 4 **General performance requirements**
- 5 **Internal atmosphere pressure**
- 6 **External atmosphere pressure**
- 7 **Internal atmosphere temperature**
- 8 **External atmosphere temperature**
- 9 **Internal atmosphere humidity**
- 10 **External atmosphere humidity**
- 11 **Seawater pressure**
- 12 **Seawater temperature**
- 13 **Ice**
- 14 **Seawater density**
- 15 **Seawater salinity**
- 16 **Surface waves**
- 17 **Static and dynamic motions**
- 18 **Seawater mist**
- 19 **Solar radiation**
- 20 **Wind**
- 21 **External airborne contaminants**
- 22 **Ingress protection**
- 23 **Marine growth**
- 24 **Vibration**
- 25 **Noise**
- 26 **Operation aground**
- 27 **Bow collision**
- 28 **Ionising radiation**
- 29 **Quality of power supplies**
- 30 **Electro-magnetic compatibility**
- 31 **Material characterisation: smoke and toxicity**
- 32 **Material characterisation: flammability**
- 33 **Material characterisation: combustibility**
- 34 **Material characterisation: corrosion**

35 **Signature qualification**

36 **Vulnerability qualification**

■ *Section 1* **Scope**

1.1 Scope

1.1.1 There are two types of transverse requirement:

- (a) Physical Transverse Criteria, which affect the systems, equipment and components; and
- (b) Transverse Process, which require policy to be defined and analysis to be undertaken in a consistent manner across the submarine systems.

1.1.2 Submarine Assurance requires transverse requirements to be defined, the impact on the systems, equipment and components to be determined, and implementation verified. This chapter describes the Physical Transverse Criteria which affect the entire platform. Transverse processes are described in *Vol 1, Pt 4, Ch 3 Requirements for Systems* to *Vol 1, Pt 4, Ch 10 Margins*.

1.1.3 Physical Transverse Criteria are to be defined by the Navy in the Concept of Operations Statement. Where criteria are not defined by the Navy, the designer's assumptions are to be stated.

1.1.4 Transverse Processes are implemented through relevant project specifications, Rules, Codes or standards which are verified through the standards justification process.

■ *Section 2* **Goals**

2.1 General

2.1.1 To identify all the Physical Transverse Criteria that may affect the submarine.

■ *Section 3* **General functional objectives**

3.1 General

3.1.1 To establish a clear definition for the Physical Transverse Criteria and the conditions in which they apply to the systems, equipment and components of the submarine.

■ *Section 4* **General performance requirements**

4.1 General

4.1.1 Physical Transverse Criteria should be defined for normal, abnormal and emergency operating conditions of the systems on board a submarine, e.g. internal pressure affected by the accidental release of a gas.

4.1.2 Physical Transverse Criteria may act in combination and have a cumulative effect. Possible interactions are to be considered in the design of the submarine, systems, equipment and components.

4.1.3 The impact of Physical Transverse Criteria on embarked personnel is to be understood and suitable limits defined.

4.1.4 The systems, equipment and components are to be verified as being effective and safe for the full range of Physical Transverse Criteria.

4.1.5 The restrictions Physical Transverse Criteria may place on submarine operation is to be documented in the operational envelope for the submarine.

■ Section 5

Internal atmosphere pressure

5.1 Functional objective

5.1.1 The internal submarine, systems, equipment and components shall be able to operate when exposed to the range of internal atmosphere pressures which can be experienced on a submarine for all foreseeable operating conditions.

5.2 Performance requirements

5.2.1 The maximum and minimum static and transient internal atmosphere pressure shall be defined for normal and abnormal operating conditions. Pressure limits are to be set taking into account internal air temperature variation.

5.2.2 Pressure limits are to be set giving due consideration to all sources of pressure or depression which vent internally or draw atmosphere from within the submarine, e.g. tank filling, venting, compressors, engines, batteries, gas powered launch systems, air induction systems.

5.2.3 The maximum and minimum transient internal atmosphere pressure shall be defined for emergency operating conditions. The following accident scenarios shall be considered: unintended munition reaction, stored gas leakage, piping system leakage, operation of fixed firefighting systems, flooding incident, flood control through pressurisation, unintended operation of machinery which consumes internal atmosphere, failure of air induction system safeguards.

5.2.4 The static and transient air pressures defined shall take account of immediate capability and longer-term health of the embarked persons.

5.2.5 The systems, equipment and components are to be verified as being effective and safe for the full range of internal atmosphere pressures.

■ Section 6

External atmosphere pressure

6.1 Functional objective

6.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of external atmospheric pressures which can be experienced by the submarine in all foreseeable operating conditions.

6.2 Performance requirements

6.2.1 The maximum and minimum static external atmospheric pressure shall be defined for areas of submarine operation.

6.2.2 The localised maximum transient pressure shall be defined for weapon system operations.

6.2.3 External blast overpressure is to be defined as a survivability requirement, *see Vol 1, Pt 4, Ch 8 Survivability*.

6.2.4 The systems, equipment and components are to be verified as being effective and safe for the full range of external atmospheric pressure.

■ *Section 7***Internal atmosphere temperature****7.1 Functional objective**

7.1.1 The internal submarine, systems, equipment and components shall be able to operate when exposed to the range of internal atmosphere temperatures which can be experienced on a submarine for all foreseeable operating conditions.

7.2 Performance requirements

7.2.1 The maximum and minimum static and transient internal atmosphere temperatures shall be defined for normal and abnormal operating conditions.

7.2.2 The maximum and minimum transient internal atmosphere temperature shall be defined for emergency operating conditions. The following scenarios shall be considered: loss of HVAC or cooling, fire, unintended munitions reactions, overload of mechanical or electrical systems, loss of cryogenic material.

7.2.3 Temperature limits are to be set giving due consideration to all sources of heating and cooling within the submarine and heat gain from solar radiation.

7.2.4 Temperatures may be defined for a compartment, or groups of compartments, and are to include any localised heating from equipment operation.

7.2.5 The atmosphere temperatures defined shall take account of the immediate capability and longer-term health of the embarked persons.

7.2.6 The systems, equipment and components are to be verified as being effective and safe for the full range of internal atmosphere temperatures.

7.2.7 Atmosphere Control requirements shall be complied with.

■ *Section 8***External atmosphere temperature****8.1 Functional objective**

8.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of external atmospheric temperatures which can be experienced by the submarine in all foreseeable operating conditions.

8.2 Performance requirements

8.2.1 The maximum and minimum static atmospheric external temperature shall be defined for areas of submarine operation.

8.2.2 External temperature from munition effects is to be defined as a survivability requirement. *See Vol 1, Pt 4, Ch 8 Survivability.*

8.2.3 The localised maximum transient temperature shall be defined for weapon system operations, e.g. missile efflux, or transition to sea water temperature, e.g. solar heated casing cooled on diving.

8.2.4 The localised maximum transient temperature shall be defined for exhaust systems and components, e.g. snort system exhaust valves.

8.2.5 The systems, equipment and components are to be verified as being effective and safe for the full range of external temperatures.

■ *Section 9***Internal atmosphere humidity****9.1 Functional objective**

9.1.1 The internal submarine, systems, equipment and components shall be able to operate when exposed to the range of internal atmosphere humidity which can be experienced on a submarine for all foreseeable operating conditions.

9.2 Performance requirements

9.2.1 operating conditions. Humidity limits are to be set taking into account internal air pressure and temperature variation for normal and abnormal operating conditions.

9.2.2 Humidity limits are to be set giving due consideration to all sources of water vapour within the submarine.

9.2.3 The range of humidity variation during submarine operation at sea and alongside is to be defined such that equipment can be tested to ensure it can accommodate the cyclic variation or be provided with suitable protection.

9.2.4 The maximum and minimum transient internal humidity shall be defined for emergency operating conditions. The following scenarios shall be considered: loss of HVAC or cooling, leaks from steam or other high temperature systems,

9.2.5 Where submarines are to be inactive for periods of time, suitable arrangements are to be provided to protect key equipment against the effects of condensation.

9.2.6 The atmosphere humidity defined shall take account of the impact on embarked persons.

9.2.7 The systems, equipment and components are to be verified as being effective and safe for the full range of internal atmosphere humidity.

9.2.8 Atmosphere Control requirements shall be complied with.

■ *Section 10***External atmosphere humidity****10.1 Functional objective**

10.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of external atmospheric humidity which can be experienced by the submarine in all foreseeable operating conditions.

10.2 Performance requirements

10.2.1 The maximum and minimum static atmospheric external humidity shall be defined for areas of submarine operation.

10.2.2 The systems, equipment and components are to be verified as being effective and safe for the full range of external humidity.

■ *Section 11***Seawater pressure****11.1 Functional objective**

11.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of water pressure which can be experienced by the submarine in all foreseeable operating conditions

11.2 Performance requirements

11.2.1 The maximum and minimum static and transient water pressure shall be defined for normal and abnormal operating conditions. The number of lifetime cycles shall be defined.

11.2.2 The maximum and minimum transient water pressure shall be defined for emergency operating conditions. The following accident scenarios shall be considered: temporary depth excursion, maximum trim.

11.2.3 The systems, equipment and components are to be verified as being effective and safe for the full range of water pressure.

11.2.4 External pressure due to underwater explosion is to be defined as a survivability requirement. See *Vol 1, Pt 4, Ch 8 Survivability*.

■ *Section 12*
Seawater temperature

12.1 Functional objective

12.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of water temperatures which can be experienced by the submarine in all foreseeable operating conditions.

12.2 Performance requirements

12.2.1 The maximum and minimum static and transient water temperature shall be defined for normal and abnormal operating conditions.

12.2.2 The systems, equipment and components are to be verified as being effective and safe for the full range of water temperature.

■ *Section 13*
Ice

13.1 Functional objective

13.1.1 The submarine, systems, equipment and components shall be able to operate in cold weather conditions where required by the Concept of Operations Statement.

13.2 Performance requirements

13.2.1 The maximum ice and snow conditions expected for the submarine operating environment are to be defined.

13.2.2 The stability of the submarine is to be sufficient with ice accretion on exposed surfaces.

13.2.3 The submarine, systems, equipment and components that are required to operate with ice accretion are to be identified. They shall be able to operate with defined levels of ice accretion or be fitted with suitable protection measures to prevent it, e.g. snort induction and exhaust systems.

13.2.4 Submarine, systems, equipment and components that are only required to operate ice free but may be exposed to ice build-up are to be identified and suitably protected and be able to withstand ice removal procedures.

13.2.5 The submarine, systems, equipment and components that are required to survive and or operate with external ice loading are to be identified. They shall be able to operate with defined levels of ice load or be fitted with suitable protection measures.

■ Section 14 Seawater density

14.1 Functional objective

14.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of water density which can be experienced by the submarine in all foreseeable operating conditions.

14.2 Performance requirements

14.2.1 The maximum and minimum static and transient water density shall be defined for normal and abnormal operating conditions. Density limits are to be set taking into account the range of seawater salinity and areas of operation.

14.2.2 The systems, equipment and components are to be verified as being effective and safe for the full range of water density.

■ Section 15 Seawater salinity

15.1 Functional objective

15.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of water salinity which can be experienced by the submarine in all foreseeable operating conditions.

15.2 Performance requirements

15.2.1 The maximum and minimum static and transient salinity shall be defined for normal and abnormal operating conditions.

15.2.2 The systems, equipment and components are to be verified as being effective and safe for the full range of salinity.

■ Section 16 Surface waves

16.1 Functional objective

16.1.1 The submarine, systems, equipment and components in exposed environments shall be able to operate when exposed to surface waves, as experienced on a submarine for all foreseeable operating conditions.

16.2 Performance requirements

16.2.1 The maximum expected sea state is to be defined for surface and near surface operation, taking account of the expected areas of operation and noting possible restrictions on diving due to depth limitations.

16.2.2 The maximum expected wave height is to be defined for normal and abnormal surface operating conditions. Access openings, snort induction and exhaust openings are to be suitably located and adequately protected against ingress from the combination of wave height and submarine motion.

16.2.3 The wave loads and the number of waves return period expected for normal and abnormal operating conditions are to be determined.

16.2.4 The submarine, systems, equipment and components that are required to operate within an exposed environment in normal, abnormal and emergency operating conditions are to be identified. They shall be able to operate with defined levels of wave impact loading or be fitted with suitable protection measures, e.g. casings, masts, bridge fin, control surfaces, communication masts, navigation lights, etc.

16.2.5 The maximum expected wave height is to be defined for emergency surface operating conditions.

■ Section 17

Static and dynamic motions

17.1 Functional objective

17.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of submarine static and dynamic motions which can be experienced on a submarine for all foreseeable operating conditions.

17.2 Performance requirements

17.2.1 The maximum submarine static and transient angles of heel, roll, trim and pitch shall be defined for normal and abnormal operating conditions.

17.2.2 The maximum submarine vertical, transverse and longitudinal accelerations shall be defined for normal and abnormal operating conditions. Accelerations should consider the surface, near surface and deep operating conditions, submarine manoeuvring capabilities, surface stability and motions from sea states defined in *Vol 1, Pt 4, Ch 2, 16 Surface waves*.

17.2.3 Submarine motions and accelerations should include dynamic effects from submarine manoeuvring, motions and weapon launch, e.g. snap roll, ejection of payload. Separate criteria may be defined for short periods of time for controlled operations.

17.2.4 The maximum static and transient hydrodynamic loads are to be defined for all external appendages and control surfaces for normal, abnormal and emergency operating conditions.

17.2.5 The maximum and minimum transient accelerations shall be defined for emergency operating conditions. The following accident scenarios shall be considered: broaching, recovery from depth excursion. For collision scenarios, see *Vol 1, Pt 4, Ch 2, 27 Bow collision*.

17.2.6 The localised maximum acceleration shall be defined for launching systems or wave impact loads, e.g. gun or weapon system.

17.2.7 Shock acceleration is to be defined as a survivability requirement.

17.2.8 The angles of heel, roll, trim pitch and accelerations defined shall take account of the impact on the embarked persons.

17.2.9 The systems, equipment and components are to be verified as being effective and safe for the full range of submarine motions.

■ Section 18

Seawater mist

18.1 Functional objective

18.1.1 The submarine, systems, equipment and components in exposed environments shall be able to operate when exposed to seawater mist experienced on a submarine for all foreseeable operating conditions.

18.2 Performance requirements

18.2.1 The submarine, systems, equipment and components that are required to operate within an exposed environment or adjacent to an exposed opening in normal operating conditions are to be identified. They shall be able to operate with defined levels of seawater mist or be fitted with suitable protection measures.

18.2.2 The submarine, systems, equipment and components that are required to survive and or operate after exposure to a seawater mist environment in normal operating conditions are to be identified. They shall be able to operate after being exposed to a seawater mist environment or be fitted with suitable protection measures.

■ Section 19

Solar radiation

19.1 Functional objective

19.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of solar radiation which can be experienced by a submarine for all foreseeable operating conditions.

19.2 Performance requirements

19.2.1 The maximum solar and ultraviolet radiation shall be defined for normal and abnormal operating conditions. Ultraviolet radiation limits are to be set taking into account areas of operation for the submarine.

19.2.2 The solar radiation defined shall take account of the immediate capability and longer-term health of the embarked persons.

19.2.3 The submarine, systems, equipment and components that are required to operate within an exposed environment in normal or abnormal operating conditions are to be identified. They shall be able to operate with defined levels of solar radiation or be fitted with suitable protection measures.

■ Section 20

Wind

20.1 Functional objective

20.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of wind speeds which can be experienced by a submarine for all foreseeable operating conditions.

20.2 Performance requirements

20.2.1 The maximum static and transient wind speed shall be defined for normal and abnormal operating conditions. Limits are to be set taking into account areas of operation for the submarine.

20.2.2 The systems, equipment and components are to be verified as being effective and safe for the full range of wind speeds.

20.2.3 Submarine, systems, equipment and components that are only required to operate in reduced wind speeds are to be identified and suitably protected and able to withstand maximum wind speeds in the stowed condition.

■ Section 21

External airborne contaminants

21.1 Functional objective

21.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of airborne contaminants which can be experienced by a submarine for all foreseeable operating conditions.

21.2 Performance requirements

21.2.1 The particulates and frequency of occurrence shall be defined for normal and abnormal operating conditions. Limits are to be set taking into account areas of operation for the submarine.

21.2.2 The submarine, systems, equipment and components that are required to operate within an exposed environment in normal operating conditions are to be identified. They shall be able to operate with defined levels of particulates or be fitted with suitable protection measures.

21.2.3 CBRN measures to enable operation in contaminated environments are defined as a survivability requirement. See *Vol 1, Pt 4, Ch 8 Survivability*.

■ Section 22 Ingress protection

22.1 Functional objective

22.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to particles and water which may be experienced on a submarine for all foreseeable operating conditions.

22.2 Performance requirements

22.2.1 The particulates, water immersion or spray, and frequency of occurrence shall be defined for normal and abnormal operating conditions.

22.2.2 The submarine, systems, equipment and components that are required to operate within a particulate laden, water spray or water immersion environment in normal and abnormal operating conditions are to be identified. They shall be able to operate with defined levels of particulates, water or immersion or be fitted with suitable protection measures.

22.2.3 The submarine, systems, equipment and components that are required to survive and or operate after exposure to a particle laden, water spray or water immersion environment in normal and abnormal operating conditions are to be identified. They shall be able to operate after being exposed to particulates, water spray or water immersion environment or be fitted with suitable protection measures.

22.2.4 The submarine, systems, equipment and components that are required to operate within a water immersion environment in emergency operating conditions are to be identified. They shall be able to operate with defined levels of immersion and external pressure, e.g. life support systems for abandonment and rescue.

22.2.5 The potential for the submarine, systems, equipment and components to release particulates or water spray shall be defined for emergency operating conditions. The following accident scenarios shall be considered: smoke, dust, fire residues, abrasion of rotating equipment, leakage of submarine systems, leakage of penetrations.

22.2.6 The submarine, systems, equipment and components that are required to operate within a particulate laden environment in emergency operating conditions are to be identified. They shall be able to operate with defined levels of particulates. The smoke environment is defined in *Vol 1, Pt 4, Ch 4 Materials*.

22.2.7 Generation of particulates shall take account of the impact on embarked persons.

■ Section 23 Marine growth

23.1 Functional objective

23.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to defined levels of marine growth which can be experienced by the submarine in all foreseeable operating conditions.

23.2 Performance requirements

23.2.1 The operating environment for the submarine and duration in each area is to be defined, including port and harbour areas where the submarine will be moored.

23.2.2 Suitable materials are to be chosen for the external and internal, systems, equipment and components exposed to seawater. Materials are to be chosen that inhibit marine growth or the components suitably protected. Where required, materials are to be suitably conditioned before installation, e.g. filters, coolers and pipework.

23.2.3 The submarine, systems, equipment and components that are required to operate with marine growth in normal operating conditions are to be identified. They shall be able to operate with defined levels of marine growth or be fitted with suitable protection measures to prevent it.

23.2.4 Submarine, systems, equipment and components that are only required to operate free from marine growth in normal operating conditions but may be exposed to marine organisms are to be suitably protected and able to withstand removal procedures.

23.2.5 The submarine, systems, equipment and components vulnerable to mould growth in normal operating conditions are to be identified and provided with suitable protection measures to prevent it.

■ Section 24 Vibration

24.1 Functional objective

24.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of mechanical vibration which can be experienced on a submarine for all foreseeable operating conditions.

24.2 Performance requirements

24.2.1 The maximum vibration levels for displacement, velocity and or acceleration shall be defined for normal and abnormal operating conditions.

24.2.2 Vibration limits are to be set giving due consideration to all sources of excitation from within and external to the submarine.

24.2.3 The localised maximum vibration levels for equipment mounted on rafts or other equipment shall be defined.

24.2.4 The vibration levels defined shall take account of the impact on the embarked persons.

24.2.5 The systems, equipment and components are to be verified as being effective and safe for the full range of vibration environments.

24.2.6 Vibration reducing measures to minimise signature are defined as a survivability requirement. See *Vol 1, Pt 4, Ch 2, 35 Signature qualification* and *Vol 1, Pt 4, Ch 8 Survivability*.

■ Section 25 Noise

25.1 Functional objective

25.1.1 The submarine embarked persons shall be able to operate when exposed to the range of noise loudness which can be experienced on a submarine for all foreseeable operating conditions.

25.2 Performance requirements

25.2.1 The maximum noise levels shall be defined for normal and abnormal operating conditions.

25.2.2 Noise limits are to be set giving due consideration to all sources of noise from within and external to the submarine.

25.2.3 The noise levels defined shall take account of the impact on the embarked persons.

25.2.4 Measures shall be taken to reduce machinery noise in machinery spaces and transmitted noise to adjacent spaces to acceptable levels, as determined by the Naval Administration.

25.2.5 Noise reducing measures to minimise signature are defined as a survivability requirement. See *Vol 1, Pt 4, Ch 2, 35 Signature qualification* and *Vol 1, Pt 4, Ch 8 Survivability*.

■ Section 26 Operation aground

26.1 Functional objective

26.1.1 The relevant submarine, systems, equipment and components shall be able to operate on the seabed for all foreseeable operating conditions.

26.2 Performance requirements

26.2.1 The seabed environments on which the submarine may rest are to be defined.

26.2.2 The impact of the grounding event on relevant elements of the submarine structure shall be determined.

26.2.3 The submarine, systems, equipment and components that are required to operate in normal and abnormal conditions with the submarine on the seabed are to be identified.

26.2.4 The submarine, systems, equipment and components that are required to operate in emergency conditions with the submarine on the seabed are to be identified.

26.2.5 Submarine, systems, equipment and components that are required to be available whilst on the seabed shall be able to operate free from ingestion of contaminants, without degradation to the levels of performance required.

26.2.6 The submarine, systems, equipment and components that are required to survive and or operate after operating on the seabed are to be identified. The loads imposed are to be defined. They shall be able to be isolated and fitted with suitable protection measures.

■ Section 27 Bow collision

27.1 Functional objective

27.1.1 The relevant submarine, systems, equipment and components shall be able to operate to a defined level following a bow impact.

27.2 Performance requirements

27.2.1 An operating concept shall be developed to describe the collision event. The consequent accelerations are to be determined.

27.2.2 The submarine, systems, equipment and components that are required to operate following the collision event are to be identified in the operating concept.

27.2.3 The impact of the collision event on relevant elements of the submarine structure shall be determined.

27.2.4 The watertight integrity of the submarine structure's penetrations shall be maintained for the defined collision event.

27.2.5 Equipment, components and their supporting structure shall remain captive in defined compartments.

27.2.6 The systems defined by the Naval Administration shall remain capable of a defined level of operation following the collision event.

27.2.7 The embarked persons shall be protected from the direct effects of the defined collision event.

■ Section 28 Ionising radiation

28.1 Functional objective

28.1.1 The relevant submarine, systems, equipment and components shall be able to operate to a defined level following a bow impact.

28.2 Performance requirements

28.2.1 The radiation levels, duration and frequency of occurrence shall be defined for normal and abnormal operating conditions in different areas of the submarine.

28.2.2 The submarine, systems, equipment and components that are required to operate when subject to radiation in normal and abnormal operating conditions are to be identified. They shall be able to operate with defined levels of exposure, or be fitted with suitable protection measures, or have a defined exposure limits with suitable margin.

28.2.3 The submarine, systems, equipment and components that are required to operate when subject to radiation in emergency operating conditions are to be identified. They shall be able to operate with defined levels of radiation, e.g. life support systems for abandonment and rescue.

28.2.4 Radiation levels shall take account of the impact on embarked persons.

28.2.5 Radiation levels shall take account of the impact on the properties of susceptible materials.

■ Section 29 Quality of power supplies

29.1 Functional objective

29.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of electrical powersupply variation which can be experienced on a submarine for all foreseeable operating conditions.

29.2 Performance requirements

29.2.1 The quality of power supplies, i.e. maximum and minimum, static and transient voltage and frequency ranges, and total harmonic distortion for electrical equipment shall be defined for normal, abnormal and emergency operating conditions in accordance with *Vol 1, Pt 4, Ch 3, 3 Software integrity and integration*.

29.2.2 The systems, equipment and components are to be verified as being effective and safe for the full range of power supply conditions.

29.2.3 Submarine, systems, equipment and components that are only able to operate in particular power supply conditions are to be identified and suitably protected.

■ Section 30 Electro-magnetic compatibility

30.1 Functional objective

30.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of electromagneticinterference which can be experienced by a submarine for all foreseeable operating conditions.

30.2 Performance requirements

30.2.1 The EM environments shall be defined throughout the submarine for normal, abnormal and emergency operating conditions in accordance with *Vol 1, Pt 4, Ch 3 Requirements for Systems*.

30.2.2 The submarine, systems, equipment and components that are required to operate and are susceptible to a particular EM environment in normal and abnormal operating conditions are to be identified. They shall be able to operate and be immune to the defined levels of interference for that location or be fitted with suitable protection measures.

30.2.3 The submarine, systems, equipment and components that are required to operate and are susceptible to a particular EM environment in emergency operating conditions are to be identified. They shall be able to operate and be immune to the defined levels of interference for that location.

■ Section 31

Material characterisation: smoke and toxicity

31.1 Functional objective

31.1.1 The submarine, systems, equipment and components shall be constructed from materials for which the by-products from exposure to elevated temperature and fire are acceptable in all foreseeable operating conditions.

31.2 Performance requirements

31.2.1 The duration of operation at elevated temperature is to be defined for all normal, abnormal and emergency operating conditions. The criteria are to be representative of expected operating conditions.

31.2.2 The submarine, systems, equipment and components that are exposed to the effects of elevated temperatures in normal, abnormal and emergency operating conditions are to be identified. Levels of smoke and toxic products released from materials exposed to elevated temperature shall be determined in accordance with a recognised standard.

31.2.3 The duration and intensity of fire for material characterisation is to be defined. The criteria are to be representative of expected fire scenarios

31.2.4 The submarine, systems, equipment and components that can be exposed to fire are to be identified in accordance with *Vol 1, Pt 4, Ch 2, 31 Material characterisation: smoke and toxicity*. The levels of smoke and toxic product generation from materials sensitive to fire shall be determined in accordance with a recognised standard.

31.2.5 Fire safety requirements are to be complied with.

■ Section 32

Material characterisation: flammability

32.1 Functional objective

32.1.1 The submarine, systems, equipment and components shall be constructed from materials for which the flammability characteristics are acceptable in all foreseeable operating conditions.

32.2 Performance requirements

32.2.1 The duration, ignition source and heat intensity for material characterisation is to be defined. The criteria are to be representative of expected fire scenarios.

32.2.2 The submarine, systems, equipment and components that can be exposed to fire are to be identified in accordance with *Vol 1, Pt 4, Ch 4 Materials*. The flammability of materials sensitive to fire shall be determined in accordance with a recognised standard.

32.2.3 Fire safety requirements are to be complied with.

■ *Section 33***Material characterisation: combustibility****33.1 Functional objective**

33.1.1 The submarine, systems, equipment and components shall be constructed from materials for which the combustibility characteristics are acceptable in all foreseeable operating conditions.

33.2 Performance requirements

33.2.1 The duration and heat intensity for material characterisation is to be defined. The criteria are to be representative of expected fire scenarios.

33.2.2 The submarine, systems, equipment and components that can be exposed to fire are to be identified in accordance with *Vol 1, Pt 4, Ch 4 Materials*. The combustibility of materials sensitive to fire shall be determined in accordance with a recognised standard.

33.2.3 Fire safety requirements are to be complied with.

■ *Section 34***Material characterisation: corrosion****34.1 Functional objective**

34.1.1 The submarine, systems, equipment and components shall be constructed from materials for which the corrosion characteristics are acceptable in all foreseeable operating conditions.

34.2 Performance requirements

34.2.1 The range of environmental conditions for corrosion characterisation is to be defined. The criteria are to be representative of submarine operating conditions.

34.2.2 The submarine, systems, equipment and components that are sensitive to corrosion are to be identified in accordance with *Vol 1, Pt 4, Ch 4 Materials*. The corrosion response of materials shall be determined in accordance with a recognised standard.

■ *Section 35***Signature qualification****35.1 Functional objective**

35.1.1 The signature of submarine, equipment and components shall be acceptable in all foreseeable operating conditions.

35.2 Performance requirements

35.2.1 The signature requirements are to be defined for all normal, abnormal and emergency operating conditions.

35.2.2 The submarine, systems, equipment and components that have signature requirements are to be identified in accordance with *Vol 1, Pt 4, Ch 8 Survivability*. The signature emission levels shall be determined in accordance with a recognised standard.

■ Section 36 Vulnerability qualification

36.1 Functional objective

36.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to the range of military threats which can be experienced by a submarine, for all foreseeable operating conditions.

36.2 Performance requirements

36.2.1 The military threat conditions shall be defined throughout the submarine for defined threat levels in accordance with *Vol 1, Pt 4, Ch 8 Survivability*.

36.2.2 The submarine, systems, equipment and components that are required to operate in normal and abnormal operating conditions that are susceptible to a particular threat environment, are to be identified. The level of performance required during and after the threat event is to be defined. They shall be able to operate to the levels defined or be fitted with suitable protection measures.

36.2.3 Capability shall be determined in accordance with a recognised standard.

Section

- 1 **Scope**
- 2 **System and equipment categories**
- 3 **Software integrity and integration**
- 4 **Quality of power supplies**
- 5 **Electromagnetic compatibility**
- 6 **Design for inspection and in-service verification**

■ *Section 1* **Scope**

1.1 Scope

1.1.1 The scope of this chapter relates to:

- (a) System, equipment and component criticality and integrity;
- (b) Software, Firmware;
- (c) General electrical compatibility; and
- (d) Design for inspection.

1.1.2 The scope includes all materials, systems, equipment and components that form the submarine.

1.1.3 The scope does not include portable devices or payload, but it does include the interfaces with the submarine systems, equipment and components.

1.1.4 The scope does include the interface with those systems outside the submarine which can impact on the submarine systems.

■ *Section 2* **System and equipment categories**

2.1 Functional objectives

2.1.1 Systems, equipment and components shall be assigned a safety criticality category based on the criticality of their function in normal, abnormal and emergency operating conditions. The integrity of the systems, equipment and components shall be commensurate with their assigned safety criticality category.

2.2 Performance requirements

2.2.1 The categorisation of systems, equipment and components shall be carried out in accordance with a categorisation process which fulfils the aims of this Section.

2.2.2 The categorisation process shall take into account both the risk assessment requirements and the whole boat requirements in *Vol 1, Pt 1, Ch 2, 4 Framework processes*.

2.2.3 The categorisation process shall be agreed by LR and all stakeholders.

2.2.4 The designer shall list all systems, equipment and components on the submarine and establish their category.

2.2.5 The categorisation process shall define the categories in relation to safety criticality and the procedure by which systems are assigned to those categories.

2.2.6 The process shall recognise system dependencies and the contribution of systems to submarine functions.

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- 2.2.7 The process shall recognise the potential impact of the systems, equipment and components on embarked persons.
- 2.2.8 Equipment and components shall be assigned the same category as the system of which they are a part. Equipment and components assigned a lower category than the system of which they are a part, shall be fully justified, with a risk assessment, safety argument and hazard analysis.
- 2.2.9 Additional specification requirements such as susceptibility, military functions or performance requirements for particular systems, equipment and components may result in those systems, equipment and components being assigned to a higher category in agreement with relevant stakeholders.
- 2.2.10 Any justification for assigning equipment and components to a lower category than the system of which they are a part based on redundancy, shall include assessments of capacity, diversity, reliability and failure modes, including common modes of failure, for all redundant equipment and components in the system and the system itself, relative to the whole boat risk assessment and safety argument.
- 2.2.11 Policies, procedures and requirements for the design and construction of systems, equipment and components, their verification and validation, shall recognise and take account of safety criticality categories and provide for the required integrity.
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■ *Section 3*

Software integrity and integration

3.1 Functional objectives

3.1.1 For any activity that relies on the integrated use of equipment or sub-systems that includes software, the risks associated with software and its integration into the equipment or sub-system shall be properly managed to ensure that for normal, abnormal and emergency operating conditions, a failure or unspecified behaviour of the software shall not result in:

- (a) An event that escalates to a hazard;
- (b) Impairment of the mitigation of a hazard; and
- (c) Impairment of recovery from a hazard.

3.2 Performance requirements

3.2.1 Software is to be designed and tested in accordance with recognised standards.

3.2.2 The ways in which software could be a stimulus event to a hazard, impair the mitigation of a hazard, or impair recovery following such a hazardous event shall be communicated to the appropriate parties.

3.2.3 The production of software shall be managed so that the safety risks arising from the software production are reduced to an acceptable level.

3.2.4 Provision shall be made to protect systems against:

- (a) Unauthorised installation, change or deletion of software or associated data;
- (b) The installation or use of unauthorised software (e.g. running games or office applications); and
- (c) Modification of the software function by additional or modified physical devices.

3.2.5 A system safety justification shall be developed to include the risks posed by the use of software and how those risks are reduced to an acceptable level.

3.2.6 The configuration status of the software on each submarine shall be captured and recorded, and the record maintained up-to-date for the life of the submarine.

3.2.7 The development and testing of changes to the software and data, including specific arrangements for onboard testing, shall be managed so that safety of the system, sub-system or equipment is not compromised.

3.2.8 The retention and release of earlier versions of software shall be managed to enable restoration of a previous known and trusted state when necessary.

3.2.9 The release and installation of software to each submarine shall be appropriately and actively managed so that changes to software are controlled. The installation process shall include a strategy for managing a failed installation.

3.2.10 Assurance of software integrity is to be provided to appropriate standards and verified by an appropriate organisation throughout the entire software lifecycle.

3.2.11 The computer-based system hosting software shall comply with electrotechnical and whole-boat requirements.

■ *Section 4*

Quality of power supplies

4.1 Functional objective

4.1.1 The range of electrical powersupply variation which can be experienced on a submarine shall be defined for all foreseeable operating conditions.

4.2 Performance requirements

4.2.1 harmonic distortion, for electrical equipment shall be defined for normal, abnormal operating and emergency conditions for each circuit.

4.2.2 Voltage and frequency permanent and transient limits are to be set giving due consideration to variations in electrical power generation and loads during normal and abnormal operating conditions, e.g. the starting and stopping of generators and consumers.

4.2.3 For electrical installations that may be supplied by batteries the quality of power supplies shall be defined throughout the specified charge and discharge cycles of the batteries.

4.2.4 The submarine, equipment and components that are required to operate on each circuit are to be identified. They shall be able to operate with the defined levels of electrical power supply variation for that circuit or be fitted with suitable protection measures.

4.2.5 Electrical equipment insulation resistance shall be sufficient for the full range of conditions defined.

■ *Section 5*

Electromagnetic compatibility

5.1 Functional objective

5.1.1 The range of electromagneticinterference which can be experienced by a submarine shall be defined for all foreseeable operating conditions.

5.1.2 The electromagnetic emissions from submarine, systems, equipment and components shall not be a risk to: the submarine systems, embarked persons, munitions or flammable atmospheres.

5.1.3 The Section does not cover portable electrical devices. These should be controlled by operating procedures.

5.2 Performance requirements

5.2.1 Electromagnetic (EM) threats are to be controlled using the appropriate methods for the EM emitters and susceptible systems, equipment or components within the submarine. This includes applying standards agreed by the Naval Administration and conducting an EM threat assessment.

5.2.2 The EM threat assessment and EM vulnerability assessment is to identify all the internal and external EM threats and vulnerabilities or hazards and identify all the processes, procedures and mitigation requirements which are to be applied to achieve the required electromagnetic compatibility (EMC) between the submarine equipment and systems. The EM Threat assessment is to consider the risk to people, explosive atmospheres and munitions associated with electromagnetic radiation.

5.2.3 EM pulse and electromagnetic signature are to be defined as a survivability and signature requirement. *See Vol 1, Pt 4, Ch 8 Survivability.*

5.2.4 The EM environment shall be defined throughout the submarine for normal, abnormal and emergency operating conditions. Limits are to be set taking into account the electrical and mission system equipment likely to be on board the submarine, personnel exposure and risk to flammable atmospheres and munitions. The definition of the EM environment shall include:

- (a) Conducted low frequency interference;
- (b) Conducted radio interference;
- (c) Radiated radio frequency fields;
- (d) Fast low-energy transients (bursts);
- (e) Slow high-energy transients (surges); and
- (f) Electrostatic discharge (ESD).

5.2.5 The localised maximum transient EM environment shall be defined for the areas where there are high power emitters which exceed the general EM environment, e.g. bridge fin.

5.2.6 The submarine, systems, equipment and components shall be protected from the effects of lightning.

5.2.7 The submarine, systems, equipment and components that are required to operate and are susceptible to a particular EM environment are to be identified. They shall be able to operate and be immune to the defined levels of interference for that location or be fitted with suitable protection measures.

5.2.8 The EM environment defined shall take account of the impact on the embarked persons, suitable control measures are to be put in place to manage exposure.

5.2.9 The EM environment defined shall take account of the impact on flammable atmospheres which may be generated in or near the submarine, and suitable control measures are to be put in place to reduce the risk of ignition. The effect of electrostatic discharge on such operations is also to be considered.

5.2.10 The EM environment defined shall take account of the impact on munitions, suitable control measures are to be put in place to reduce the risk of a munition reaction.

5.2.11 An EMC Management Plan shall be provided which details the submarine's operational role and defines the EM environment in normal, abnormal and emergency operating conditions, required submarine functions in the different EM environments, EM systems requirements and organisational responsibilities.

5.2.12 An EMC Control Plan shall be provided which defines the design and mitigation measures to be taken to achieve EMC in the agreed EM threat environment. These are to include, but are not limited to the following:

- (a) The EM threats;
- (b) The zoning concept used;
- (c) Exposure limits for personnel, munitions and hazardous atmospheres;
- (d) A declaration of the emission levels;
- (e) A declaration the minimum immunity level;
- (f) Shielding techniques and requirements;
- (g) Cabling requirements;
- (h) Filtering requirements; and
- (i) Grounding requirements.

5.2.13 Levels of EM emission from the submarine equipment shall be known.

5.2.14 An EMC Test Plan shall be provided which defines the verification and validation requirements, which are to include the analysis, inspection, demonstration and testing requirements. The EMC test plan is to include verification of the EM environment.

5.2.15 The EMC Management Plan, EMC Control plan, and EMC Test plan are to be maintained for the life of the submarine and updated following modification or change. The effect of modifications and changes are to be evaluated to confirm performance requirements continue to be met.

■ *Section 6***Design for inspection and in-service verification****6.1 Functional objective**

6.1.1 The submarine, systems, equipment and components shall be designed to enable safe and effective monitoring and inspection for in-service verification for all foreseeable operating conditions, where inspection is required to maintain operation.

6.2 Performance requirements

6.2.1 The submarine, systems, equipment and components shall be designed so that they are able to be:

- (a) Monitored for key parameters;
- (b) Isolated and deenergised for inspection, maintenance or replacement;
- (c) Accessed for inspection of the material state;
- (d) Accessed for maintenance or replacement; and
- (e) Examined and tested to validate integrity and performance.

6.2.2 Examination, testing and inspection are to be possible without:

- (a) Creating a hazard; and
- (b) Requiring system modification.

6.2.3 Systems, equipment, and components test procedures are to be designed to eliminate the risk of maloperation during testing and inspection and return to normal use, e.g. accidental over pressurisation.

6.2.4 Systems should be designed so that they degrade gradually to enable deterioration to be detected with sufficient time before failure.

6.2.5 Systems, equipment or components which are not able to be inspected during the life of the submarine are to be provided with an engineering justification considering criticality, rates of degradation, redundancy and remote monitoring.

6.2.6 Survey, inspection and maintenance periods are to be defined. Intended inspection plan and maintenance routines are to be defined. Component life is to be determined and provided to the Navy.

6.2.7 Survey, inspection and test requirements shall be provided which defines the monitoring, access, inspection, and testing requirements.

Section

- 1 **Scope**
- 2 **Suitability of materials**
- 3 **Hazardous materials**
- 4 **Material smoke and toxicity control**
- 5 **Material flammability and combustibility control**
- 6 **Material corrosion control**
- 7 **Control of hazardous materials**

■ *Section 1* **Scope**

1.1 Scope

1.1.1 The scope of this Chapter relates to the following:

- (a) Quantifying risks associated with materials on board a submarine;
- (b) Characterisation of materials; and
- (c) Materials management.

1.1.2 The scope includes the materials used to construct all systems, equipment and components permanently fixed in the submarine.

1.1.3 The scope does not include consumable stores and portable equipment. Similar restrictions will apply, but these are to be managed through the Submarine Safety Management System.

1.1.4 This section does apply to the storage of fixed equipment and materials before installation on the submarine, where inappropriate storage or preparation could degrade the material or negatively impact submarine safety.

1.1.5 This section does not address equipment, component and materials traceability which is required by *Vol 1, Pt 3, Ch 5, 3 Product verification*.

■ *Section 2* **Suitability of materials**

2.1 Functional objective

2.1.1 The submarine, systems, equipment and components shall be constructed from materials which do not pose a hazard to the embarked persons or the submarine in any foreseeable operating conditions.

2.2 Performance requirements

2.2.1 The materials forming the submarine, systems, equipment and components shall be suitable for the component life, submarine service life, and planned maintenance and inspection intervals.

2.2.2 The materials forming the submarine, systems, equipment and components shall not pose a hazard to the embarked persons noting the extended duration of submarine operating conditions. Where the use of such materials is required for operational reasons, the Naval Administration may permit their use based on a suitable justification being provided and mitigations to manage the hazards being put in place.

2.2.3 Materials which are banned or restricted by national or international legislation due to their known hazards to human health or the environment shall not be used. Where the use of such materials is required for operational reasons, the Naval Administration may permit their use based on a suitable justification being provided and mitigations to manage the hazards being put in place.

2.2.4 A method for controlling the installation of banned or restricted materials shall be provided.

2.2.5 The combination of dissimilar materials shall not cause an adverse reaction or pose a danger to embarked persons.

2.2.6 Materials used on the submarine are to be appropriately stored before their use, to prevent degradation and adequately prepared, so they are suitable for use onboard.

2.2.7 Materials are to be suitable for the signature requirements of the submarine. *See Vol 1, Pt 4, Ch 8 Survivability.*

2.2.8 Suitability of materials under shock loading is to be defined as a survivability requirement. *See Vol 1, Pt 4, Ch 8 Survivability.*

■ *Section 3* **Hazardous materials**

3.1 Functional objective

3.1.1 Hazardous materials shall be managed effectively to identify, reduce and mitigate adverse effects on the submarine or embarked persons.

3.2 Performance requirements

3.2.1 The submarine shall have a system to identify and manage hazardous materials and to restrict or mitigate known hazards.

3.2.2 The risks posed by hazardous materials shall be communicated to the embarked persons and training provided as necessary in their handling and management.

3.2.3 A method for identifying controlling the installation of hazardous materials shall be provided.

■ *Section 4* **Material smoke and toxicity control**

4.1 Functional objective

4.1.1 The submarine, systems, equipment and components shall be constructed from materials for which the by-products from exposure to elevated temperature and fire are controlled in all foreseeable operating conditions.

4.1.2 The submarine, systems, equipment and components shall be able to operate when exposed to the range of smoke and toxic products from fire which can be experienced on a submarine in emergency conditions.

4.2 Performance requirements

4.2.1 Smoke and toxic products released from materials exposed to the effects of fire in emergency operating conditions are to be limited. Levels of smoke and toxic product generation from the submarine, systems, equipment and components exposed to fire shall be known.

4.2.2 Smoke and toxic products released from materials exposed to the effects of elevated temperature in normal, abnormal and emergency operating conditions are to be limited. Levels of smoke and toxic product generation from the submarine, systems, equipment and components exposed to elevated temperatures shall be known. *See Vol 1, Pt 4, Ch 2, 31 Material characterisation: smoke and toxicity.*

4.2.3 The submarine, systems, equipment and components sensitive to smoke and fire by-products products are to be identified. They shall be able to operate with defined levels of smoke and toxic products generated by fire in emergency operating conditions or be fitted with suitable protection measures. *See Vol 1, Pt 4, Ch 2, 22 Ingress protection.*

4.2.4 Levels of smoke and toxic products generated from fire are to be assessed for their impact on embarked persons.

4.2.5 Where the use of materials that exceed the smoke and toxic product criteria is required for operational reasons, the Naval Administration may permit their use based on a suitable justification being provided and mitigations to manage the hazards being put in place.

4.2.6 A method for identifying and controlling the installation of materials that exceed the acceptable criteria shall be provided.

■ *Section 5*

Material flammability and combustibility control

5.1 Functional objective

5.1.1 The submarine, systems, equipment and components shall be constructed from materials and use fluids for which the flammability and combustibility is controlled in all foreseeable operating conditions.

5.2 Performance requirements

5.2.1 The use of flammable and combustible materials or fluids is to be limited. Levels of flammability and combustibility of the submarine, systems, equipment and components when exposed to fire in emergency operating conditions shall be known.

5.2.2 Where the use of materials that exceed the flammability and combustibility criteria is required for operational reasons, the Naval Administration may permit their use based on a suitable justification being provided and mitigations to manage the hazards being put in place.

5.2.3 A method for identifying and controlling the installation of materials or use of fluids that exceed the acceptable criteria shall be provided.

■ *Section 6*

Material corrosion control

6.1 Functional objective

6.1.1 The submarine, systems, equipment and components shall be provided with suitable corrosion prevention appropriate for the environmental conditions foreseeable and possible periods of inspection.

6.2 Performance requirements

6.2.1 The inspection survey and access requirements for the submarine, systems, equipment and components are to be defined.

6.2.2 The range of internal and external environmental conditions for the life of the submarine are to be defined. *See Vol 1, Pt 4, Ch 2 Transverse Criteria.*

6.2.3 Suitable corrosion prevention measures for the submarine, systems, equipment and components are to be identified, these are to be appropriate for the design life of the submarine and proposed maintenance regime.

6.2.4 The combination of dissimilar materials shall not cause adverse corrosion.

6.2.5 A method for identifying and controlling the installation of materials that are sensitive to corrosion, where degradation may adversely affect the safety and integrity of the submarine shall be provided.

■ *Section 7*
Control of hazardous materials

7.1 Functional objective

7.1.1 Materials which present a direct risk to the submarine or embarked persons shall be managed effectively.

7.2 Performance requirements

7.2.1 The submarine shall have a system to identify and demonstrate control of: restricted, banned or hazardous materials and materials which exceed, smoke, toxicity or flammability criteria.

7.2.2 A method of characterising controlled materials shall be provided.

7.2.3 A method of recording the installation of controlled materials in the submarine shall be provided.

7.2.4 The risks posed by controlled materials shall be communicated to the embarked persons and training provided as necessary in their handling and management.

7.2.5 The record of controlled materials is to be maintained for the life of the submarine and updated following modification or change.

*Section***1 Scope****2 Functional objectives****3 Performance requirements**

**■ Section 1
Scope****1.1 Scope**

1.1.1 The requirements of this Chapter address the principles of human-centred design and ergonomics in the design and construction of submarines.

1.1.2 The requirements of this Chapter provide for:

- (a) The hazards associated with personnel at control stations and the related physical hazards;
 - (b) Cognitive aspects of control station design for both traditional and computer-based control; and
 - (c) General lighting and task lighting.
-

**■ Section 2
Functional objectives****2.1 Functional objectives**

2.1.1 The layout of different equipment and local control facilities shall be such that human operation is logical to embarked persons and can be performed without mistakes or violations.

2.1.2 Arrangements for control of machinery and equipment (including those for abnormal and emergency operation) shall not pose a risk to embarked persons.

2.1.3 Abnormal and emergency arrangements for machinery and equipment shall not pose a risk to embarked persons.

**■ Section 3
Performance requirements****3.1 Performance requirements**

3.1.1 The following areas are to be designed with consideration for the human element:

- (a) The submarine control positions;
- (b) The machinery control position;
- (c) Operating from the bridge fin during surface operations; and
- (d) Other conning and control positions as agreed with the Naval Administration.

3.1.2 The layout of control positions shall enhance usability and reduce human error in operator's tasks in all foreseeable manning and operating conditions.

3.1.3 The working environment shall be designed to be safe, have the minimum of distractions, be sufficiently comfortable, help to maintain vigilance, and maximise communication amongst operators at main control stations.

3.1.4 User interfaces shall be designed to provide an appropriate combination of visual, audible or mechanical feedback, to enhance the usability of systems and equipment, reduce human error, enhance situational awareness, and support safe and effective monitoring, control and supervision under normal and reasonably foreseeable, abnormal and emergency operating conditions.

3.1.5 The design of lighting shall facilitate visual task performance, operator safety and visual comfort and is to include:

- (a) Positioning and installation;
- (b) Luminance distribution;
- (c) Glare;
- (d) Location of lighting controls and outlets; and
- (e) Night vision while surfaced.

3.1.6 Equipment shall be operable and maintainable by embarked persons wearing clothing and equipment required for normal, abnormal and emergency operations and conditions. To include:

- (a) CBRN clothing/equipment;
- (b) Firefighting equipment
- (c) Anti-flash clothing;
- (d) Life-saving equipment; and
- (e) Task specific PPE.

Section

- 1 **Scope**
 - 2 **Functional objectives**
 - 3 **Performance requirements**
-

■ *Section 1*
Scope

1.1 Scope

1.1.1 The requirements of this Chapter address the impact of local hazardous atmospheres on the submarine due to the leakage of stored fluids and gases or evolved gases from equipment and machinery. In particular the impact on:

- (a) Embarked persons; and
- (b) Equipment operating in flammable atmospheres.

1.1.2 Control of the submarine atmosphere to maintain the health of embarked persons. Atmosphere Control requirements shall be complied with.

■ *Section 2*
Functional objectives

2.1 Functional objectives

2.1.1 Machinery and systems located in hazardous atmospheres shall be designed to comply with the temperature limits defined within the hazardous area.

2.1.2 The risks to embarked persons associated with hazardous atmospheres shall be minimised.

■ *Section 3*
Performance requirements

3.1 Performance requirements

3.1.1 The submarine, systems, equipment and components that may lead to a hazardous atmosphere are to be identified.

3.1.2 Hazardous atmospheres shall include the following for normal and abnormal operating conditions:

- (a) Areas where fuel vapours may accumulate due to machinery operation or maintenance;
- (b) Areas where explosive gas mixtures may accumulate due to equipment operation or maintenance, e.g. evolution of hydrogen;
- (c) Flammable liquid and gas storage, e.g. oxygen for breathing systems;
- (d) Munitions storage compartments;
- (e) Operation or maintenance of sewage processing or storage systems, e.g. hydrogen sulphide; and
- (f) Operation or maintenance of refrigeration systems.

3.1.3 Hazardous atmospheres shall be defined for emergency operating conditions. The following accident scenarios shall be considered:

- (a) Flammable liquid vapours due to system leakage, e.g. fuel, hydraulics;
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- (b) Flammable liquid vapours from crank case emergency venting;
 - (c) Explosive gas mixtures due to leakage from systems, e.g. stored oxygen or CO₂;
 - (d) Hazardous or poisonous gas mixtures due to system leakage, e.g. hydrogen sulphide from sewage plant, carbon monoxide from engine exhausts e.g. leakage of oxygen cylinder;
 - (e) Adverse reactions from fluid mixtures, gases and solids; and
 - (f) Oxygen depletion due to leakage from systems, e.g. refrigerant gas, gaseous firefighting equipment.

3.1.4 The submarine, systems, equipment and components that are required to operate within a hazardous atmosphere are to be identified. They shall be able to operate within a defined hazardous atmosphere or be fitted with suitable protection measures.

3.1.5 The categorisation of areas with potentially flammable atmospheres shall be in accordance with a national or international standard agreed by the Naval Administration.

3.1.6 Electrical machinery and systems shall not normally be located in spaces with potentially flammable atmospheres during normal or abnormal operation, unless required for operational purposes and agreed by the Naval Administration.

3.1.7 Where machinery or electrical equipment is required to be fitted in a space with a potentially flammable atmosphere, it shall be of a type suitable for the environment for which it will be operated.

3.1.8 Where machinery is operated in a potentially flammable atmosphere, a means shall be provided to detect any abnormal parameters which may lead to ignition of the atmosphere.

3.1.9 Any failure that can create a hazardous atmosphere shall be indicated by an alert.

3.1.10 The integrity of the boundary of the hazardous atmosphere shall be sufficient to maintain the safety of any adjacent space.

3.1.11 Suitable indication of the nature of the potential hazards shall be provided at the entrance(s) to the space, and on the equipment where applicable.

3.1.12 Arrangements to prevent unauthorised or inadvertent access to areas with hazardous or potentially hazardous atmosphere or equipment shall be provided in accordance with Naval Administration requirements.

3.1.13 Persons, equipment and platform shall be protected from the risk of static electricity.

3.1.14 Any area with a hazardous or potentially hazardous atmosphere which has a risk of persons becoming inadvertently locked in shall have a means to escape.

3.1.15 Any area in which a failure can lead to an atmosphere harmful for embarked persons is to be provided with monitoring and alarms.

3.1.16 Permanent means are to be provided to safely remove or make safe a hazardous atmosphere generated by submarine equipment during normal or abnormal operations.

*Section***1 Scope****2 Functional objectives****3 Performance requirements**

■ Section 1
Scope**1.1 Scope**

1.1.1 The purpose of this Chapter is to provide a framework for the hazard identification and risk assessment required to demonstrate that the submarine, systems and equipment can be operated at an agreed level of safety.

1.1.2 The risk assessments and their outputs combined with outputs from the submarine assurance process, will provide evidence to support submarine operation at an agreed level of safety.

■ Section 2
Functional objectives**2.1 Functional objectives**

2.1.1 A suitable process is to be adopted that will identify, analyse, evaluate and manage hazards associated with the operation of the submarine, systems and equipment in all reasonably foreseeable, normal, abnormal and emergency operating conditions.

2.1.2 The tolerable level of risk is to be established and agreed with the Naval Administration.

2.1.3 Assessments are to be undertaken at several levels: whole boat, for key functions, systems and equipment during the full lifecycle of the submarine design.

2.1.4 The impact of modifications, changes or degradation of the submarine on the safety and assumptions used in the risk assessment are to be evaluated.

■ Section 3
Performance requirements**3.1 Process**

3.1.1 A process is to be established for the management of submarine safety in accordance with recognised standards. The process should include a definition of the:

- (a) Activities to be carried out;
- (b) Required inputs and outputs;
- (c) Roles and responsibilities of key personnel;
- (d) Competence of key personnel;
- (e) Schedules for the activities; and
- (f) Records to be made and retained.

3.1.2 A risk management procedure is to be established in order to ensure that risks are addressed, in particular risks associated with:

- (a) Structural and watertight integrity;
- (b) Power and propulsion, power generation and distribution;
- (c) Submarine control systems: manoeuvring;
- (d) Ballast, trim and compensating system;
- (e) Munitions handling;
- (f) Life support systems; and
- (g) Integrated damage control and fire protection system.

3.1.3 The procedure is to consider the hazards associated with installation, operation, maintenance and disposal of the system, component or product in normal, abnormal and emergency operating conditions.

3.1.4 The procedure is to identify all relevant stakeholders and stakeholder requirements.

3.1.5 The procedure is to take account of the operating context, *see Vol 1, Pt 2, Ch 2, 1 Concept*.

3.1.6 The procedure is to ensure that hazards are identified using acceptable and recognised hazard identification techniques and that the effects of the following influences are considered:

- (a) Operations that the submarine is intended to perform as defined in the Concept of Operations Statement during trials, in-service, while docking and in harbour, including mission specific activities with degraded and reversionary modes of operation;
- (b) Submarine conditions under all reasonably foreseeable normal, abnormal and emergency operating conditions arising from failures or misuse of ship equipment or systems;
- (c) Configurations and modes of operation provided for the intended control of submarine systems;
- (d) The environmental conditions that the systems, equipment and components will experience due to their location within the submarine and due to the geographical location in which the submarine operates, *see Vol 1, Pt 4, Ch 2 Transverse Criteria*;
- (e) The reliance and effects on the operation of systems, equipment and components of the provision and availability of supplies and services and user interaction, including assessment of interdependencies; and
- (f) The environmental impact of the submarine throughout its lifecycle, including disposal.

3.1.7 The procedure is to ensure that risks are analysed using acceptable and recognised risk assessment techniques, and that the following consequences are considered:

- (a) Loss of function;
- (b) Loss of services essential to the safety of the submarine, services essential to the safety of embarked personnel and services essential to the protection of the environment;
- (c) Damage to components; and
- (d) Damage caused by fire, explosion, electric shock, harmful releases and hazardous releases.

3.1.8 The procedure is to ensure that risks are eliminated wherever possible. Risks which cannot be eliminated are to be mitigated as necessary.

3.1.9 Details of risks, and the means by which they are mitigated, are to be included in the operating manual.

3.2 Tolerability of risk

3.2.1 Appropriate targets are to be set for the risk to the individual, group risk and for the loss of the submarine and these are to be agreed with the Naval Administration.

3.2.2 Targets are to reflect the full range of possible consequences for the submarine and embarked persons.

3.3 Risk assessment process

3.3.1 Risk assessments are to be undertaken using an acceptable and recognised technique carried out in accordance with the relevant International Standard or applicable National Standard. A justification is to be provided which demonstrates the suitability of the standard and analysis technique chosen.

3.3.2 The risk assessment is to demonstrate that adequate risk mitigation has been achieved for all normal, abnormal and emergency conditions identified. The scope of analysis required is to:

- (a) Identify the equipment or sub-system and their modes of operation and the equipment;
- (b) Identify potential failure modes and damage situations and their causes;
- (c) Evaluate the effects on the system of each failure mode and damage situation;

- (d) Identify measures for reducing the risks associated with each failure mode;
- (e) Identify measures for failure mitigation; and
- (f) Identify trials and testing necessary to prove conclusions.

3.3.3 Normal, abnormal and emergency foreseeable conditions are to be identified using a formal and rigorous process:

- (a) Using analysis processes that are capable of revealing abnormal conditions;
- (b) Employing a mix of personnel including: designers, Operators, persons who carry out maintenance, those with relevant domain knowledge and understanding and competent safety/risk professionals to apply the processes;
- (c) Referencing relevant events and historic data; and
- (d) Documenting the results of the analysis.

3.3.4 The risk assessment is to be organised in terms of items of equipment and function. The effects of item failures or damage at stated levels and at higher levels are to be analysed to determine the effects on the system as a whole. Actions for mitigation are to be determined.

3.3.5 Suitable records are to be made of the risk assessment activity including methods of assessment, assumptions, design basis assessed and recommendations.

3.4 Modification and change

3.4.1 Where changes are made to the submarine or the Concept of Operations Statement, the risk assessments undertaken are to be reviewed to determine if the change affects the assumptions made in the assessment. If necessary, the risk assessments are to be repeated.

3.4.2 The impact of the change is to be assessed for all systems, equipment and components influenced by that change.

3.4.3 The records of the risk assessment and analysis are to be maintained and held for the lifetime of the submarine.

Section

- 1 **Scope**
- 2 **Signatures**
- 3 **Electromagnetic pulse**
- 4 **Shock and whipping**
- 5 **External blast**
- 6 **Fragmentation and small arms**
- 7 **Chemical, Biological, Radiological and Nuclear protection (CBRN)**
- 8 **Recoverability**

■ *Section 1* **Scope**

1.1 Scope

1.1.1 The scope of this Chapter is as follows:

- (a) The vulnerability of the submarine, i.e. the ability of the submarine to resist the effects of weapon attack;
- (b) The susceptibility of the submarine, i.e. the ability of the submarine to reduce its signature and disturbance of the environment in which it operates; and
- (c) Recoverability, which is a measure of the ability of the submarine to improve functionality and capability post damage from extreme threats.

1.1.2 The scope includes both assessments undertaken to determine capability and additional equipment, systems or features fitted to improve survivability.

■ *Section 2* **Signatures**

2.1 Functional objectives

2.1.1 To reduce the susceptibility of a submarine to a military attack by controlling the signature of the submarine to a level defined by the Navy, through the design of the submarine.

2.1.2 The safety implications of operating in the low signature state are to be assessed.

2.2 Performance requirements

2.2.1 The Navy is to define required signature thresholds for different operating conditions. Sufficient information is to be provided to enable the verification activities to be effective.

2.2.2 The Navy is to define the operating environment and conditions in which low signature operation will be required.

2.2.3 As a minimum, the signature policy communicated to LR shall address the safety of the submarine when operating in various low signature states. Sufficient machinery is to be available during all low signature states to provide for the safety of submarine functions and embarked persons, in particular:

- (a) Strength and integrity;
- (b) Manoeuvring and control;

- (c) Power and propulsion;
- (d) Provision, storage and distribution of electrical power;
- (e) Support and protection of life; and
- (f) Munitions handling.

2.2.4 An analysis is to be undertaken to determine the low signature performance of the submarine.

2.2.5 Systems, equipment and components are to be designed to achieve the signature levels required. The capability of equipment required to operate in the low signature state is to be demonstrated through testing or analysis.

2.2.6 Machinery not required for low signature states should be suitably isolated to prevent operation.

2.2.7 Machinery not required for low signature states is to be prevented from automatic starting or changeover during a low signature state.

2.2.8 Control and alarm systems should be suitable for operation in a low signature state.

2.2.9 Material selection for systems, equipment and components is to recognise the signature requirements.

2.2.10 The submarine, systems are to be subject to testing and trials to demonstrate the signature levels.

2.2.11 Survey and inspection is to be undertaken to ensure the signature hygiene levels are maintained.

2.2.12 Procedures are to be in place to control noise emissions from the submarine when operating in the low noise state.

■ *Section 3* **Electromagnetic pulse**

3.1 Functional objectives

3.1.1 The submarine, systems, equipment and components shall be able to operate when exposed to an electromagnetic pulse (EMP) which may be experienced on a submarine in foreseeable operating conditions.

3.2 Performance requirements

3.2.1 The Navy is to define EMP strengths and frequency spectrum.

3.2.2 The submarine, systems, equipment and components that are required to operate within an EMP environment in extreme conditions are to be identified. They shall be able to operate with defined levels of electromagnetic interference or be fitted with suitable protection measures.

3.2.3 The submarine, systems, equipment and components that are required to survive and/or operate after exposure to an EMP environment in extreme conditions are to be identified. They shall be able to operate after being exposed to an EMP environment or be fitted with suitable protection measures.

3.2.4 Procedures are to be in place to protect the embarked persons from the direct effects of EMP and effects of EMP on systems, equipment and components.

■ *Section 4* **Shock and whipping**

4.1 Functional objectives

4.1.1 The submarine structure, systems and equipment are to be designed to withstand the effects of a defined underwater explosion at a specified distance from the submarine. Measures are to be taken to reduce the risk of injury to embarked persons.

4.1.2 The policy shall address the effects on the submarines systems of an initial shock wave resulting from a single underwater explosion that is sufficiently distant to exclude jet formation and contact effects.

4.1.3 Whipping effects after the initial shock pulse are also to be considered.

4.2 Shock event performance requirements

4.2.1 A shock system operating concept shall be developed to describe the magnitude and nature of the shock event. It shall identify the compartments, systems and equipment to be protected and the expected performance during and after the shock event.

4.2.2 The shock event shall be assessed to determine the likelihood of whipping of the submarine. Where appropriate, the whipping effects on equipment are to be considered.

4.3 Pressure hull performance requirements

4.3.1 The impact of the shock event on relevant elements of the submarine structure shall be determined by testing or analysis to define the shock loading environment for the equipment and systems.

4.3.2 The watertight integrity of the submarine structure, penetrations, defined internal pressure boundaries and internal tank boundaries shall not be compromised by the defined shock event.

4.3.3 The integrity of the submarine pressure hull structure shall not be compromised by the whipping effects from the defined shock event.

4.3.4 The Naval Administration may define additional integrity requirements for external structure, appendages, propulsion equipment, and control systems essential to the operation of the submarine.

4.4 Equipment and systems performance requirements

4.4.1 Equipment, components and their supporting structure shall remain captive in defined compartments.

4.4.2 The systems defined by the Naval Administration are to remain capable of a defined level of operation following a defined shock event.

4.5 People performance requirements

4.5.1 The embarked persons are to be protected from the direct effects of the defined shock event.

4.5.2 Procedures and training are to be established to enable embarked persons to prepare for the defined shock event.

**■ Section 5
External blast****5.1 Functional objectives**

5.1.1 The submarine structure, systems and equipment are to be designed to withstand the effects of a defined external blast at a specified distance from the submarine. Measures are to be taken to reduce the risk of injury to embarked persons.

5.1.2 As a minimum, the external blast policy will provide sufficient protection to essential structure, systems and personnel in the event of a defined external blast event, which shall:

- (a) Ensure that exposed structure remains effective and capable of protecting submarine functions and personnel;
- (b) Ensure that essential load-bearing structure remains effective and capable of supporting load;
- (c) Ensure that fittings and closures remain effective and capable of operating in an emergency situation; and
- (d) Ensure that embarked persons are not at an increased risk of injury.

5.2 Performance requirements

5.2.1 An external blast system operating concept shall be developed, to define the magnitude and nature of the blast event, pressure and duration. It shall identify the compartments, systems and equipment to be protected and the expected performance during and after the blast event.

5.2.2 Structures protecting external above water compartments containing essential systems or personnel shall be capable of withstanding a specified blast event without collapse or deformation that would prevent operation.

5.2.3 Load-bearing external structures shall be capable of withstanding a specified blast event without an appreciable reduction in their ability to carry load.

5.2.4 Essential fittings and closures shall be capable of withstanding a specified blast event and its effects without a loss in functionality or integrity of the system or boundary into which they are fitted.

5.2.5 Failure of a fitting or closure due to a specified blast event shall not present an increased danger to essential systems or personnel on board either by its inability to operate or its failure.

5.2.6 Where required, the structure, fittings and closures shall preserve the integrity level specified for the maintenance of the CBRN defence boundaries following a specified blast event.

5.2.7 Where required, the structure providing protection to embarked persons shall be capable of withstanding the defined threat.

■ *Section 6* **Fragmentation and small arms**

6.1 Functional objectives

6.1.1 The submarine structure, systems and equipment are to be designed to withstand the effects of a defined fragmentation and small arms threat. Measures are to be taken to reduce the risk of injury to embarked persons.

6.1.2 As a minimum, the fragmentation and small arms protection policy will provide sufficient protection to essential structure, systems and personnel in the event of a defined threat, which shall:

- (a) Ensure that exposed systems, equipment and components providing submarine functions are protected and remain effective;
- (b) Ensure that structure preserving watertight integrity remains effective;
- (c) Ensure that fittings and closures remain effective and capable of operating in an emergency situation; and
- (d) Ensure that embarked persons are not at an increased risk of injury.

6.2 Performance requirements

6.2.1 A fragmentation and small arms operating concept shall be developed to define the magnitude and nature of the threat. It shall identify the compartments, systems and equipment to be protected.

6.2.2 Structures protecting external, above water, compartments containing essential systems, munitions or personnel shall be capable of withstanding the defined threat.

6.2.3 Failure of a fitting or closure due to a defined threat shall not present an increased danger to essential systems or personnel on board either by its inability to operate or its failure.

6.2.4 Where required, the structure providing protection to embarked persons shall be capable of withstanding the defined threat.

■ *Section 7* **Chemical, Biological, Radiological and Nuclear protection (CBRN)**

7.1 Functional objectives

7.1.1 The submarine structure, systems and equipment are to be designed to withstand the effects of Chemical, Biological, Radiological, and Nuclear contaminants. Measures are to be taken to reduce the risk of injury to embarked persons.

7.2 Performance requirements

7.2.1 A Chemical, Biological, Radiological, and Nuclear protection operating concept shall be developed to define the magnitude and nature of the threats and submarine operating conditions. It shall identify the compartments which are exposed and protected.

7.2.2 A monitoring and detection system is to be provided to detect the presence of a threat and to identify the contaminants. Detection is to be provided for the external atmosphere and the internal spaces which may become contaminated in particular operating conditions.

7.2.3 Where required, protection of the internal atmosphere is to be provided by air filtration systems in normal and abnormal operating conditions.

7.2.4 Arrangements are to be provided for personnel to enter and exit the submarine in protective clothing. Suitable cleaning and decontamination facilities are to be provided to prevent contamination of the internal atmosphere.

7.2.5 Where internal spaces are intended to be contaminated, suitable access arrangements and gas tight boundaries are to be provided. Arrangements are to be provided for personnel to enter and exit the space in protective clothing. Suitable cleaning and decontamination facilities are to be provided to prevent contamination of the internal atmosphere.

■ *Section 8* **Recoverability**

8.1 Functional objectives

8.1.1 In case of damage, the capability of essential safety functions and other defined services shall be maintained and/or recovered to a defined level.

8.2 Performance requirements

8.2.1 A Recoverability operating concept shall be developed to define the functions and systems required to operate following an incident. The type and magnitude of the incidents to be survived are to be defined.

8.2.2 Sufficient systems and stored energy shall be provided following a damage incident to support safe abandonment.

8.2.3 Sufficient systems may be provided to the extent required by the operating concept to enable embarked persons to remain on board in the event of an incident. Submarine functions shall be provided for the maximum time to rescue specified in the operating concept with angles of heel and trim appropriate for emergency operation.

- (a) Atmosphere control to maintain support to life;
- (b) Safety systems to support internal and external communications;
- (c) Safety systems to contain the current damage and manage further incidents;
- (d) Arrangements to enable movement of people to safe locations and to support orderly evacuation and abandonment if the condition degrades due to further incidents;
- (e) Structural strength of internal structure giving due regard to the post damage conditions specified;
- (f) Maintain conditions for dangerous goods and embarked equipment such that they remain in a safe state; and
- (g) Habitability systems and supplies to maintain basic health and sanitary conditions.

8.2.4 Where required, Post Damage Capability may provide for the following functions following a defined damage type and extent:

- (a) Safety systems to support situational awareness and facilitate safe navigation and external communications;
- (b) Stability and Controllability appropriate for safe navigation;
- (c) Propulsion to allow the submarine to move to a safe haven within a suitable time based on the conditions specified; and
- (d) Damage Control Stations to ensure adequate management of the damage event and adequate operation, control and monitoring of the remaining functions post damage.

8.2.5 Embarked persons are to be provided with suitable operator information for operation in the damaged state.

Section

- 1 **Scope**
- 2 **Functional objectives**
- 3 **Performance requirements**

■ *Section 1* **Scope**

1.1 Scope

1.1.1 The purpose of this Chapter is to provide a framework for the management of obsolescence for submarine, systems, equipment and components.

1.1.2 Obsolescence is to be managed for systems, equipment and components which impact on the function and safety of the submarine.

■ *Section 2* **Functional objectives**

2.1 Functional objectives

2.1.1 Obsolescence shall be managed by the Navy, designer, builder and their supply chains throughout the lifecycle of the submarine.

2.1.2 The submarine, systems, equipment and components shall be designed to consider obsolescence.

2.1.3 Assessments are to be undertaken to determine the impact of obsolescence on the submarine systems, equipment and components.

■ *Section 3* **Performance requirements**

3.1 Policy and principles

3.1.1 An obsolescence management plan shall be provided which references the Navy obsolescence policy and defines: organisational roles and responsibilities, principles, activities, monitoring, reporting and methods of evaluation.

3.1.2 Design principles are to be defined to mitigate the impact of obsolete systems, equipment and components. The principles are to be communicated to the designer, builder and supply chain. They may address:

- (a) Modular design;
- (b) Interface specification;
- (c) Supply chain agreements;
- (d) Preservation of tools, design and manufacturing knowledge;
- (e) Use of open standards;
- (f) Sustainable technology;
- (g) Multiple supply lines;
- (h) Advance purchase; and
- (i) Planned replacement refresh or upgrade.

3.2 Assessment

3.2.1 An obsolescence assessment is to be undertaken to determine the risk, likely timeframes and methods of control associated with obsolescence.

3.2.2 The systems, equipment and components shall be decomposed to an appropriate level whereby the obsolescence risk can be adequately determined to derive actions and methods of control. The decomposition shall consider physical assets, consumables, materials, software, systems and services. The decomposition may consider consumables, skills and supporting services. The criticality of the component, product or system to submarine function and safety shall be determined.

3.2.3 An assessment of the obsolescence risks shall be made for critical systems, equipment and components taking account of: change in technologies, commercial viability, availability of subcomponents or materials, loss of manufacturing capability, loss of skills or knowledge, regulatory or legal impact, licences, geopolitical influences and natural disasters.

3.2.4 Actions and methods of control to manage obsolescence risks are to be identified and their implementation managed.

3.3 Monitoring and review

3.3.1 Arrangements are to be provided for monitoring and managing obsolescence notices, legislation changes and loss of suppliers.

3.3.2 The obsolescence assessment is to be reviewed and updated on a regular basis and following change or modification of the submarine systems, equipment and components.

3.3.3 Actions and methods of control to manage obsolescence risks are to be monitored and actively managed through the submarine lifecycle.

3.3.4 Where replacement parts are no longer available, an engineering justification is to be provided for alternative solutions.

3.3.5 Alternative solutions are to comply with Design Verification and Product Verification requirements.

3.4 Planned replacement

3.4.1 A plan is to be provided for the removal of systems, equipment and components which have a limited life, or which are highly likely to become obsolete before the end to the submarine design life.

3.4.2 The systems, equipment and components with a limited design life are to be provided with sufficient life at the start of build or replaced at start of submarine trials.

Section

- 1 **Scope**
- 2 **Functional objectives**
- 3 **Performance requirements**

■ *Section 1* **Scope**

1.1 Scope

1.1.1 The purpose of this Chapter is to provide a framework for the management of design, build and in-service margins for the submarine.

■ *Section 2* **Functional objectives**

2.1 Functional objectives

- 2.1.1 A flexible, transparent and appropriate margin management policy shall be agreed between the designer, builder and Navy.
- 2.1.2 Margins shall be defined for key engineering parameters which require management and control to achieve a coherent design.
- 2.1.3 Margins shall be agreed, monitored and revised at appropriate points during the life cycle of the submarine.

■ *Section 3* **Performance requirements**

3.1 Policy and principles

3.1.1 A margin management plan shall be provided which references the Navy margin policy and defines: organisational roles and responsibilities, principles, activities, monitoring, reporting and methods of evaluation.

3.1.2 Design Margins are to be defined for key engineering variables which have the potential to threaten the viability of the submarine design if not adequately managed. Margins may be defined for:

- (a) Weights and centres (VCG, LCG, TCG);
- (b) Space;
- (c) Electrical Power;
- (d) HVAC System and atmosphere control;
- (e) Chilled Water; and
- (f) PMS Bandwidth and processing.

3.2 Assessment

3.2.1 Budgets are to be agreed for the following lifecycle stages and provided with suitable justification.

- (a) Design;

- (b) Build;
- (c) Modification;
- (d) Growth; and
- (e) Capability upgrade.

3.2.2 The budgets for systems, equipment and components shall be decomposed to an appropriate level where by the engineering variables can be adequately determined and measured. Responsibility for managing the engineering variables is to be assigned to relevant individuals.

3.2.3 Key systems, equipment and components which have a significant impact on an engineering variable shall be identified and specific monitoring and control measures defined.

3.3 Monitoring and review

3.3.1 Suitable processes are to be established to allow estimates to be made of the engineering variables and to collate accurate information from the supply chain. Information is to be updated with a frequency appropriate to the uncertainty or risk associated with the systems, equipment and components.

3.3.2 Where required specific systems, equipment and components are to be tested to verify the engineering variables.

3.3.3 The estimates and margins are to be reviewed and updated on a regular basis during the design and build phase and reported at key milestones. The estimates and margins are to be reviewed and updated following change or modification of the systems, equipment and components.

3.3.4 The margins are to be measured, reviewed and updated during operation and following change or modification of the submarine.

3.3.5 Information on margin assumptions, growth and changes is to be appropriately captured and stored to inform future projects.

Section

1 Terms, definitions and Acronyms related to Part 4

■ Section 1 Terms, definitions and Acronyms related to Part 4

1.1 Definitions

1.1.1 The following terms and definitions are relevant:

- **Abnormal operation.** Conditions in which the Submarine can be foreseen to operate in a degraded, aged and/or damaged state, defined in the Concept of Operations Statement. Abnormal operating conditions will usually be associated with a conscious imposition of operating restrictions following foreseeable damage or loss of function. (e.g. a depth/ speed restriction, limiting the duration of a mission, reduced function for defined reversionary modes etc.).
- **Accident.** An identifiable event or series of events which can be foreseen but which is unexpected.
- **Combustibility.** The ability of a material to ignite and burn when exposed to heat.
- **Dangerous goods.** As defined in the UN Recommendations on the Transport of Dangerous Goods – Model Regulations.
- **Emergency operation.** Conditions in which a degree of function is required following an Accident or Extreme Threat Damage
- **Essential safety function.** Where the loss of function will be likely to place the submarine or individual crew members in danger of hazard in the near future unless mitigating factors are applied. Loss of essential safety functions may also cause a reduction in the ability of the submarine to respond to other incidents. For example, loss of a containment function may not be an immediate threat if containment is not needed, but it is essential since, due to its failure, containment would not be possible when required.
- **Flammability.** The ability of a material to burn with a flame under specified conditions.
- **Flood.** Ingress of external sea water from a pressure hull fracture, piping system or component failure. Generally, an emergency operating condition. Will be able to be controlled by the submarine up to a defined size of leak.
- **Functional objective.** A series of requirements which define the scope of the document or section. They typically identify subject areas or process steps.
- **Goal.** A high-level statement which describes in general terms, the primary requirement of the document or section.
- **Leak.** Escape of liquid or gas from a piping system or component. Generally a normal or abnormal operating condition which would usually be able to be controlled by the submarine.
- **Normal operation.** Conditions in which the submarine can be foreseen to operate in an intact condition with all systems available and operating within design parameters as defined in the Concept of Operations Statement. (e.g. depth/ speed, sea ice, persons embarked etc.).
- **Performance requirement.** A set of statements which define the requirements for the functional objective. They are to be independent of the technical solutions and are qualitative.
- **Piping system.** Includes pipes and fittings such as expansion joints, valves, pipe joints, support arrangements, flexible tube lengths etc. and components in direct connection with the piping such as pumps, heat exchangers, air receivers, independent tanks, etc. It does not include main and auxiliary machinery such as diesel engines, electric propulsion motors steam and gas turbines, boilers, reduction gears, etc.
- **Safety function.** As detailed in *Vol 1, Pt 1 General* and summarised here, in order to comply with the aims of the Assurance Framework, a submarine must provide certain safety functions. Other, non-safety functions, such as 'military', are not in scope, but may clearly follow the same system, using an additional categorisation process advised by stakeholders. The safety functions have an effective tier system although some safety functions have broadly equivalent tiers – as shown by the numbers.
- **Software.** All or part of the programs, procedures, rules and associated documentation of an information-processing system.
- **Submerged.** For the purpose of this framework, a condition whereby the entire submarine is below the surface of the water, and it is not possible to deploy any masts from this depth. In this Chapter, it is understood that the AIS system cannot be made to ventilate or exhaust at this depth.

- **Transient.** A short duration event where the deviation from the static condition will have an effect on the submarine, systems, equipment or embarked persons.
- **Physical transverse criteria.** These are actual properties, influences, forces or constraints that apply to all components in a submarine. Examples include shock, environmental conditions and signature. These properties are to be adequately defined for normal, abnormal and emergency operating conditions. Processes for their verification and acceptance are to be agreed with LR.
- **Transverse process.** These are processes, methodologies, calculations and practices which are applied to all parts of the design and concept of the submarine. These include risk assessment, systems engineering, hazard identification, software assurance and safety assessment. Analytical transverse elements are to be applied to all relevant aspects of the design of a component, product or system. The output from the process or assessment must be applied to the whole submarine design.
- **Verification.** For the purposes of this Chapter verification is a survey, test, inspection or other regime for gathering objective evidence that a product is in compliance with a validated Rule, standard or other specification.

1.2 Acronyms

1.2.1 The following Acronyms are relevant:

None specific to this part

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